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The brachiopods of the Duncannon Group (Middle-Upper Ordovician) of southeast Ireland

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CONTENTS

Synopsis. Brachiopod assemblages from localities within the Duncannon Group of the Leinster terrane, southeast Ireland, are systematically described and figured. The localities were known to 19th century geologists but have been largely ignored since then. Re-collection permits a revised correlation between the Leinster localities and successions of adjacent terranes. The faunal assemblages are all of Caradoc age. Kildare (Grange Hill), Ballygarvan Bridge, Greenville-Moyne, Ballykale, Carrigadaggan and Kilbride are all probably Longvillian, whilst the faunas from Kildare Grange Hill House Cottage, Clologe, Greenville and Raheen are of probable Soudleyan, or possibly Harnagian, age. Brachiopods dominate the Duncannon faunas. One new species, *Petrocrania harperi* and one new subspecies, *Leptestiina oepiki ampla* are described.

The brachiopods are closely related to coeval Anglo-Welsh Province faunas, with many conspecific forms. The origins of the genera can be found mainly in earlier migrations of Baltic Province genera, although some Scoto-Appalachian genera are present as early immigrants, implying a mid-Ordovician phase of breakdown of Iapetus brachiopod provinciality. The faunas occur in volcano-sedimentary sequences, reflecting their palaeogeographical position in a volcanic arc marginal to the Eastern Avalonia microcontinent. This moved northward throughout the Ordovician, acting as a staging post for inter-provincial migrations, until its collision with Baltica and Laurentia.

Comparison of the assemblages reveals no direct similarities with Welsh palaeocommunities, although strong inter-locality resemblance is noted, despite the occurrence of varied lithologies. Except for the molluscan-dominated Soudleyan Kildare fauna, which resembles that at Herbertstown, assemblages indicate a normal marine environment in moderate to deep water surrounding volcanic centres.

INTRODUCTION

This work presents the results of re-collection and re-examination of many fossiliferous localities within the late Llandeilo and Caradoc strata of southeast Ireland. The area of research is confined to the NE–SW Caledonide trending belt of volcanic and sedimentary rocks of the Duncannon Group, extending from Co. Wicklow through Co. Wexford to south Co. Waterford; it also includes the peripheral Kildare inlier of Co. Kildare. The faunas are all early to middle Caradoc in age, and they are dominated mainly by brachiopods, with components of trilobites, gastropods, bivalves, bryozoans, crinoids, cystoids and orthocones.

Brachiopods are one of the most useful animal groups in Ordovician sequences for stratigraphical and environmental interpretation in non-graptolitic strata, so the emphasis of the present work is on their identification and description. Trilobites, although numerically a minor component of the faunas, are also discussed, but their detailed systematics will be presented separately by Dr A. Owen and this author. The preservation of almost all fossil material is as internal or external moulds and this makes identification of some elements, such as bryozoans, gastropods and bivalves, difficult. These elements are counted and listed in the relevant faunas,

but they are not identified or figured.

Limits of research area

With one exception, the boundaries of the Leinster terrane (Harper and Parkes 1989, Murphy *et al.* 1991) define the area, within which, outcrops of the various formations which make up the Duncannon Group were all examined. The rocks of the Tramore region south of Waterford were the subject of a Ph.D. research project by Hilary Carlisle at Queen's University, Belfast. Although an important paper (Carlisle 1979) summarized her main work, the Ph.D. thesis was never completed. The completion of the brachiopod systematics of the Tramore Limestone Formation is in progress by Carlisle, Dr D.A.T. Harper and the present author. The only locality from which her material was lost was Kilbride, in the Upper Tramore Volcanic Formation, and this important locality was re-collected.

The area of research, apart from the main belt of Duncannon Group rocks from Arklow through Gorey and Enniscorthy to the Waterford region, also takes in the Wicklow-Avoca volcanics and the Kildare inlier to the north-west (Fig. 1). Although the Ordovician greywackes of the Kilcullen Group to the west of the Leinster Granite, in west Wicklow, have yielded some fossils in the past, after literature research and a cursory reconnaissance, this area was not studied, since Brück (1971) has thoroughly revised the known Geological Survey of Ireland (G.S.I.) fossil localities.

Outside this area in the Iapetus suture zone of eastern Ireland, the present research has involved some restricted fieldwork and literature work to draw comparisons and contrasts between the faunas of the Leinster terrane and those of the Bellewstown and Grangegeeth terranes. The only case where detailed investigation has taken place involves a new record of shelly fossils in the Llanvirn Hilltown Formation of the Bellewstown terrane (Harper *et al.* 1991).

Revision of Duncannon Group faunas

In the Caledonides of western Europe and the eastern United States and Canada, many areas have been the subject of detailed modern palaeontological studies, often resulting in monographic treatment of the more important fauna. In the case of Wales, the Welsh Borderland and Girvan in Scotland, many Ordovician successions have been revised. These include the Bala area of North Wales (Williams 1963), the Shelve district of Shropshire (Williams 1974), Girvan in southwest Scotland (Williams 1962), Anglesey (Bates 1968), mid and southwest Wales (Lockley & Williams 1981, Williams *et al.* 1981), various areas of North Wales (Pickerill & Brenchley 1979, Lockley 1980, Hiller 1980 and Bates 1969) and the type upper Caradoc of Shropshire (Hurst 1979*a*).

Although some localities in Ireland have received modern taxonomic treatment, such as the Tourmakeady Limestone in Co. Mayo (Williams & Curry 1985) and the Portrane Limestone in north Co. Dublin (Wright 1963, 1964), the area considered here has received only partial revision and attention. Brenchley *et al.* (1977) completed a reappraisal of several Caradoc localities in eastern Ireland, including Slieveroe near Rathdrum, some sites around Enniscorthy (Greenville, Greenville-Moyne) and the successions at Bellewstown and Grangegeeth; their paper was a fundamental resource for the present work.

The present work repairs an omission in providing a modern description of the faunas in the southeast of Ireland, an area very poorly known by comparison with coeval successions in other parts of Ireland and Britain. In terms of biogeographical models the Leinster terrane occupies a pivotal position in cross Iapetus migrations, being the most external or marginal area of the Eastern Avalonia microcontinent and occupying a progessively more axial position within the closing Iapetus ocean in the Ordovician. As a chain of volcanic islands the Duncannon Group environments provided staging posts in the dispersal of shelly benthos with larval juvenile stages. The localities described herein are important in charting the migration of different species between the platform provinces of Laurentia, Baltica, Gondwana and the microcontinental terranes including Avalonia.

Although, with few exceptions, the existence of the faunas described here was known to geologists in the 19th century, progress in understanding palaeontological concepts and the concomitant increase in differentiation of species has been such that the faunal lists published by the early collectors are now of little more use than as a provisional guide. One 'species' of the 19th century may now be recognized as comprising three or four different genera. Examples include '*Leptaena sericea*' for plectambonitoid genera, '*Orthis calligramma*' for impunctate orthoid genera and '*Orthis testudinaria*' for punctate orthoids.

HISTORY OF RESEARCH

19th century research

The major reference to the faunas is that of M'Coy (1846), whose description of the fossils collected by many workers under the direction of Sir Richard Griffith (in his attempts to make the first geological map of Ireland) was done largely without knowledge of the localities or lithologies and was thus a considerable achievement. The efforts of Griffith, and his relationship with the official Ordnance Survey, as well as to the geological community in Ireland, is a fascinating story related by Herries Davies (1983), who has made clear that in many aspects the lead in geological mapping and thinking came from the G.S.I., and this affected progress in the Geological Surveys of England, Scotland and Wales.

In the 19th century some major works describing Irish geology and palaeontology included the third edition of *Siluria* (Murchison 1859) and Davidson's fine monographs of British 'Silurian' Brachiopoda (1853, 1866, 1867, 1869, 1871, 1883). In addition, noteworthy works include those of Reynolds & Gardiner on several specific areas including the Kildare Inlier (1896). Also important was Reed, who published papers on the Tramore area of Co. Waterford (1895, 1899, 1900).

1900–1950

After the initial mapping of Ireland was completed by the G.S.I. in 1890 with the publication of 1″ Sheet 10, there was very little new research of note or new interpretations in the following 70 years. In 1939 the Geologist's Association published a collection of papers on S.E. Ireland, including Hallissy (*in* Smyth, 1939) on the present study area. A

significant precursor to new investigations was a review paper by J.C. Harper (1948).

1950–1992

After the middle of the 20th century there were 3 main 'schools' of research developed in relation to the geology of S.E. Ireland that were important to this research.

J.C. Harper, based in Liverpool. Stemming from the interest and research of J.C. Harper in Irish Lower Palaeozoic geology, a series of papers by him and colleagues was presented. The most significant for this study is Brenchley *et al.* (1977), revising some successions in eastern Ireland based on new collections of fossils from Greenville, Enniscorthy, Slieveroe and Grangegeeth. Others of note are Harper & Rast (1964) on the Bellewstown succession; Crimes & Crossley (1968) and Brenchley & Treagus (1970) on the Courtown succession; Brenchley *et al.* (1967*b*) on the Tagoat faunas in the Rosslare terrane; Harper (1952) and Brenchley *et al.* (1967*a*) on the Grangegeeth inlier and Romano (1980*a*, 1980*b*) on the eastern Ireland Ordovician inliers. France (1967) also listed Caradoc fossils from Balbriggan.

Queen's University Belfast. A succession of work on Ordovician rocks in Leinster was also completed under the guidance of Alwyn Williams in Queen's University Belfast. Aside from Wright's researches at Kildare there was work by Carlisle (1979) on the Tramore area, Hiller (1971) on the Courtown rocks, and Mitchell (Mitchell *et al.* 1972) on both areas. Mitchell (1977) also subsequently completed a major revision of the Pomeroy inlier in Co. Tyrone.

Geological Survey of Ireland. Under G.S.I. instigation the Leinster area was remapped. Gardiner (1967) remapped the Duncannon area of S. Wexford and elucidated the structure (1970) and stratigraphy (1974) of the region. The area to the north but not adjoining, between Wexford and New Ross, was remapped by Shannon, who described the stratigraphy and sedimentology (1978, 1980), structure (1977, 1979*b*) and petrology (1979*a*). More recently the area to the north in Co. Wexford has been remapped by Geraghty (1989) and the area further north, extending to Co. Wicklow, was the subject of an M.Sc. thesis by Martinez (1987). This Wexford research and work by Downes (1974), Boland (1983) and Carlisle (1979) in the Tramore region have recently been compiled by the G.S.I. and new maps are in production. Also, Brück *et al.* (1978, 1979) refer to many publications based on aspects other than palaeontological research.

Recent research. This has been focussed on terrane tectonics and its application to understanding the development of the Irish Caledonides within the Iapetus Ocean (Murphy *et al.* 1991). Harper & Parkes (1989) have outlined the palaeontological constraints on the definition and development of Irish Caledonide terranes.

INFORMATION SOURCES FOR FOSSIL LOCALITIES

The primary source of information for tracing fossil localities in this study were the memoirs of the G.S.I., which list all fossiliferous sites encountered during the G.S.I. mapping programme in the mid 19th century. Locality information is restricted to a townland name (a townland is a small land area) and a quarter sheet of the six inch (1:10560) series of topographic Ordnance Survey maps. However, some localities are misplaced.

Another primary source of data was M'Coy's (1846) *Synopsis of the Silurian Fossils of Ireland.* The locality information given by M'Coy was vague, with a townland name being the smallest area unit used to identify sites. This may explain why different faunas and lithologies were lumped together under one townland name. One of the main workers who collected for Griffith was John Kelly, who recognized that the locality information given by M'Coy was poor and gave more precise details of known localities (Kelly 1860).

Apart from these major sources, published works detailed in relevant sections provided further information, the most important of these being Brenchley *et al.* (1977). Significant information was obtained by direct contacts with other researchers and local farmers. The thoroughness of the G.S.I. mapping programme and of the other 19th century geologists is clearly shown by the fact that no new fossil localities were found despite extensive fieldwork.

LOCALITY INFORMATION BY 1″ GEOLOGICAL SURVEY OF IRELAND SHEET

Figure 1A shows the 1″ geological sheets examined completely or in part in this research. This section gives all relevant information on the fossil localities on each sheet, whether or not any collection was made by the author, and the current status of the site where known. Fig. 1B is a location map of the main localities collected, and the sections illustrated on Fig. 14 (p.126) plus other locations discussed in the text.

Sheet 119

The only Ordovician fossil localities on this sheet are discussed by Baily (*in* Jukes *et al.*, 1858). They all occur within the Kildare Inlier and have been revised (Parkes and Palmer 1994).

Sheet 120

Seven localities are listed in the memoir for this sheet (Hull 1880). They were all examined recently by Brück (1971) and dealt with thoroughly. No further work was attempted for this study, and no new localities are known.

Sheets 121 and 130

This memoir (Jukes & Du Noyer 1869) does not tabulate fossil localities. Four 'Lower Silurian' localities are referred to, all in the area of Rathdrum, Co. Wicklow.

(i) Rathdrum Hill, Kilcommon, Co. Wicklow, 30/1 or 3/30 (of the 6″ series) in grey sandy beds. This locality was not found on G.S.I. 6″ fieldsheets and no fossiliferous rocks were located in the area in reconnaissance fieldwork.

(ii) Quarry near Rathdrum Bridge, on road to Glenealy and Wicklow, townland of Glasnarget north, Co. Wicklow 30 (?) in cleaved slate. The locality details are somewhat vague and the site was not found on the G.S.I. 6″ fieldsheets, but is believed to be a quarry now occupied

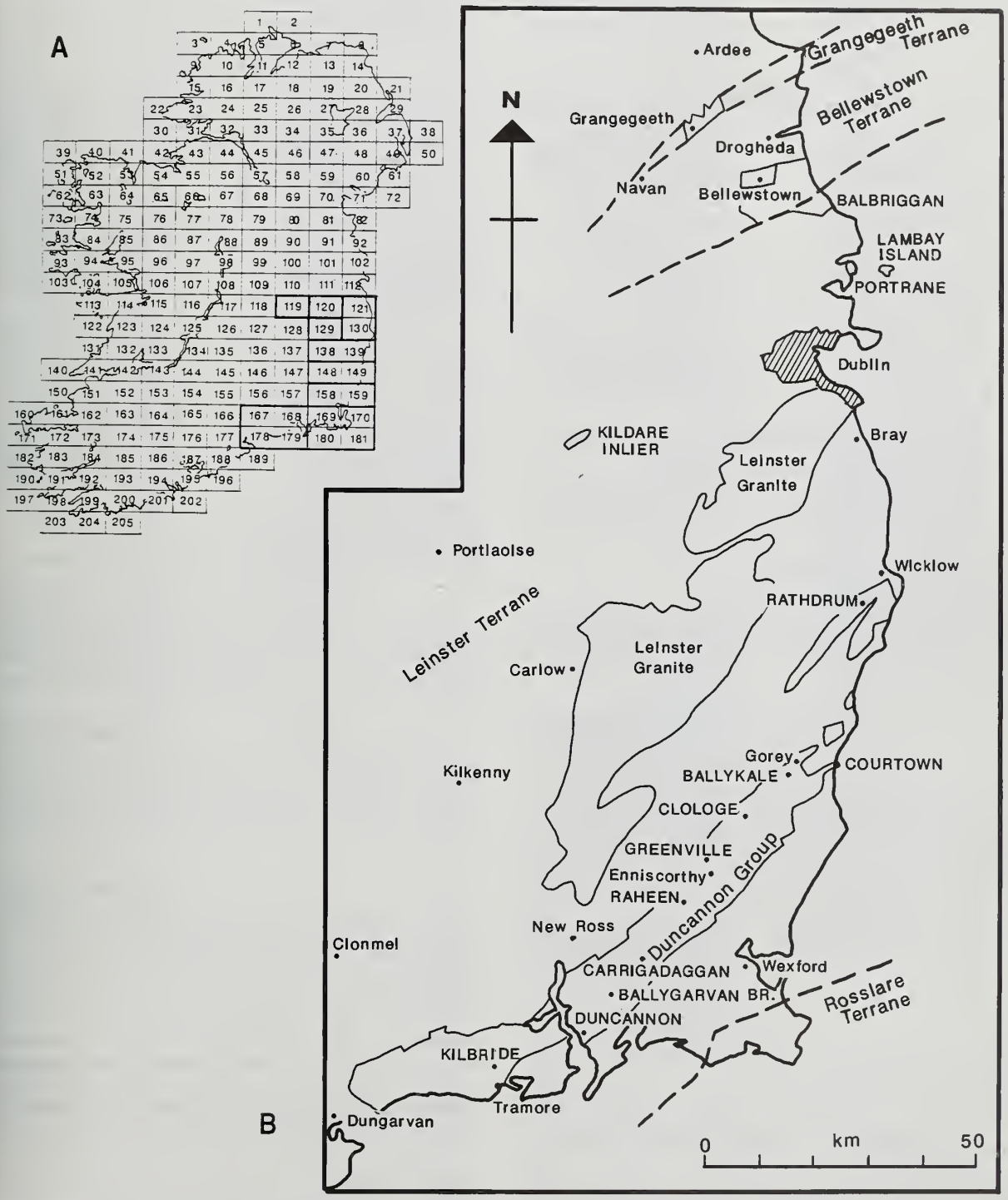

Fig. 1 A, index map of Geological Survey of Ireland 1-inch sheets examined in whole or part for revision of fossil localities. B, location map for the main sections shown on Fig. 14 (p. 126), and other localities in the Leinster terrane and adjoining terranes.

Table 1 Localities from G.S.I. Memoir examined in Sheets 148 and 149, with present status.

Loc. no.	¼ sheet of 6″ map	County & townland	Situation & geological formation & 1″ map
		Wexford	Sheet 148
1	16/1	Clologe, Upper	From debris, in field close to road, from Norris Mount to Milltown, 1mile S of Camolin; light grey & brown slates, & tuffose rock. See later section.
2	20/1	Killabeg	Quarry on bank of R. Bann, 1 mile S of Clone Wood & 3 miles S of Ferns; black slates. Graptolite loc. – not examined.
3	20/2	Ballydonegan	On road from The Harrow to Tinnacross, 1 mile SW of The Harrow; grey shales. No exposure found here.
		Wexford	Sheet 149
4	7/4	Kildermot	See Courtown localities.
5	7/4	″	″
6	7/4	″	″
7	7/4	Ballymoney, Lr.	″
8	7/4	Seafield	″
9	11/2	Ballykale	See later section.
10	11/2	Coolnaveagh	About 2 miles S of Gorey a little W of Ballinatray Bridge; black slates. Not located.
11	11/3	Ballydaniel	One mile W of Balloughter; bluish grey compact altered rock. No fossils found here.
12	11/4	Clogh and	A little SE and SW of Clogh.
		Frankfort	See later section.
13	12/1	Ballinatray, Lr.	See Courtown localities.
14	12/1	″	″
15	12/1	″	″
16	12/1	Seamount	″
17	12/2	Duffcarrick	″
18	12/3	Coolnahinch	A little SW of Ballywalter House, 2·5 miles S of Gorey. Not traced.
19	12/4	Seamount	Graptolite locality in Ribband Group – not examined.

Table 2 Localities from the G.S.I. Memoir examined in Sheet 158, with present status.

Loc. no.	¼ sheet of 6″ map	County & townland	Situation & geological formation & 1″ map
		Wexford	Sheet 158
1	19/4	Kiltrea	Graptolite loc. See Brenchley et al. (1967).
2	20/3	Moyne Upper	Quarry near road, a little S of Moyne House, 1·5 miles N of Enniscorthy; dark grey slates. Quarry now infilled – no exposure at all. See Brenchley et al. (1977) for faunal lists from collecting in that revision.
3	20/1	Moyne Lower	A little NE of Moyne House, 2 miles N of Enniscorthy; light bluish shales, weathering brown. No exposure at present.
4	20/3	Greenville & Moyne Upper	Old quarry, 1 mile N of Enniscorthy; dark grey shales. Fauna collected here in large blocks from newly ploughed strawberry field immediately adjacent to quarry. See later section.
5	20/3	Greenville	See later section.
6	20/3	Clonhasten & Ballynacarny boundary	Between Ballynabarny House and White's Bridge, 1·5 miles NE of Enniscorthy; dark grey slates. This site was not examined in this study or by Brenchley et al. (1977).
7	31/2	Ballybrennan	A little N of Ballybrennan House, 1·5 miles W of Clonmore, & about 6 miles SW of Enniscorthy; grey shales and grits. Shannon (1979a) recorded fossils here but no exposure is now available.
8	31/1	Raheen	Near Chapel Village, 6 miles SW of Enniscorthy; light grey shales & grits. See later section.

by a religious grotto about 100m from the bridge at Rathdrum. However, no fauna was found in the very slaty rock there.

(iii) Wicklow 30/3 one mile on road from Rathdrum to Redcross. This was considered too obscure and the supposed specimens too poor even in 1869 and no attempt was made to trace the locality in this study.

(iv) An old road cutting in the townland of Slieveroe, Co. Wicklow 30/1. This is discussed in brief below.

Sheet 129

The memoir for this sheet (Mitchell 1884) has one palaeontological note by W.H. Baily concerning the only known locality at Ballintaggart, Co. Kildare. This was examined by Brück (1971) in his examination of fossil localities west of the Leinster granite, and is not included here.

Sheets 138 and 139

Hull (1888), author of the G.S.I. memoir, mentions the only fossil locality in the text (p.8). A graptolite locality with poorly preserved forms 'allied to, or identical with *Graptolithus Sedgwickii*' was known a short distance NW of Arklow. The author has recently traced and curated these

Table 3 Localties from the G.S.I. Memoir examined in Sheet 168, with present status.

Loc. no.	¼ sheet of 6″ map	County & townland	Situation & geological formation & 1″ map
		Waterford	Sheet 168
1	9/4	Gibbet Hill	New road cutting on S side of R. Suir, a little NW of Waterford; black argillaceous slates. Graptolite locality, not examined.
2	17/4	Killure	Old quarry at the back of Farm House, 3 miles S of Waterford, on the road to Clohernagh Bridge; brown calcareous impure limestone. G.S.I. 6″ fieldsheets were not accessed for this area and it was not traced.
3	18/4	Raheen	Rocks on shore, a little N of Newtown Head, Waterford Harbour; dark grey concretionary shales. Owen et al. (1986) have revised the trilobite fauna. D.A.T. Harper is revising the brachiopod assemblage from here.

Table 4 Localities from the G.S.I. Memoir examined in Sheet 169, with present status.

Loc. no.	¼ sheet of 6″ map	County & townland	Situation & geological formation & 1″ map
		Wexford	Sheet 169
1	35/1 & 2	Carrigadaggan	About 1·5 miles SE of Ballynabola; grey shales. See later section.
2	35/4	Newbawn	A little N of Newbawn, 1·5 miles SE of preceding locality; grey shales. No fossiliferous exposure found here. A new quarry exposure with fossils was recently reported to me (pers. comm. M. Allen) but not visited in this research.
3	40/1	Ballygarvan	A little S of Ballygarvan Bridge, 3 miles SW of preceding locality; grey shales. See later section.
4	45/4	Ballymadder	Rocks on shore a little W of Ballymadder Point; dark grey shales. Reconnaisance visit only made here. No fossils located. Dan Tietzsch-Tyler (pers. comm. 1986) did not find significant fossils while mapping the area in detail.
5	45/4	Loftusacre	Rocks on shore W of preceding locality; grey micaceous and argillaceous shales. Same comment as loc. 4 applies.

specimens in the G.S.I. collections. They have been identified by Dr. A. Rushton, and indicate an early Ordovician, possibly Arenig age (John Morris G.S.I., pers. comm., 1994).

Sheets 148 and 149

This memoir (Hardman 1887) has palaeontological notes by W.H. Baily, who tabulated the localities. These are reproduced here with relevant information from this revision (Table 1).

Sheets 158 and 159

W.H. Baily contributed palaeontological information to this memoir (Kinahan 1882), again tabulating the fossil localities and listing the fossils collected. These are listed here with applicable information from this work (Table 2). All are from Sheet 158; none were known from Sheet 159.

Sheets 167, 168, 178 and 179

This memoir (Du Noyer 1865) also has palaeontological notes by W.H. Baily, who listed the fossils collected and tabulated the localities on Sheets 168, 178 and 179 (none were known from Sheet 167). The area of Sheet 167 is largely Caradoc or Silurian and has been studied by Penney (1980), who discussed recent faunal dating (p.319), including a Caradoc graptolite record from the Ross Formation. Sheet 178 to the west of the main Tramore volcanics is also outside the scope of this research as discussed in the Introduction. Similarly, Sheet 179 is all outside the confines of the present project and the subject of revision by D.A.T. Harper, H. Carlisle and myself. The area is described by Carlisle (1979).

However, the Kilbride locality discussed below is within the confines of Sheet 179 and adjacent to localities 13–16. It is worth noting the confusion caused in the past by the similarity of the names of Newtown Head in Waterford Harbour (locality 3 – Raheen, but not the Raheen near Enniscorthy) and that of Newtown Cove, Great Newtown Head and Newtown Glen, all on the west side of Tramore Bay, fossiliferous strata being found at all locations. Sheet 168 contains three localities, shown in Table 3.

Sheets 169, 170, 180 and 181

Kinahan (1879) wrote the memoir to the four sheets covering southeast Co. Wexford, with W.H. Baily again contributing palaeontological information in tabulated form. Sheet 169 is the one relevant to this study. The table of 'Lower Silurian' localities is reproduced here with updated information (Table 4).

Sheet 170 has two listed localities which are part of the Rosslare terrane and whose faunas were described by Brenchley *et al.* (1967*b*). These are currently being reassessed by Harper & Bates (in prep). Sheet 180 has only one graptolite locality, visited but not yielding any specimens; recent workers have not found any trace of them and suggest the deformation is too strong to preserve fossils (Gardiner

1967: 6). Sheet 181 has no fossil localities at all.

A further significant point to note in connection with the composite list of fossils collected from these sheets is that in the sections on 'Lower Silurian' trilobites, brachiopods and graptolites many species are recorded from Locality 12. This is definitely a Carboniferous locality. According to the G.S.I. Map Curator, A.G. Sleeman (personal communication, 1988), these records are actually from Localities 16 and 17, which are both in the Tagoat area of the Rosslare terrane. He detailed many further complexities resulting from 'some rather sloppy curating going on in the 19th century'. These errors clearly show the need for caution in utilizing the existing faunal lists alone in modern interpretative work.

DETAILED LOCALITY INFORMATION

The Kildare Inlier, Co. Kildare (1:126720 – SHEET 16, N724175 – Horizons 1 & 2, N724179 – Grange Hill Cottage)

This inlier is described in detail elsewhere (Parkes and Palmer 1994). Only two main horizons and one minor one have been sampled extensively for the present work. All are of Caradoc age and on the flanks of the andesites of Grange Hill. The three localities sampled are shown in Fig. 2. The older fauna at the back of the ruined farm cottage, called Grange Hill House Cottage herein, is on the northern side of Grange Hill, on the edge of the common land. Grange Hill Horizons 1 and 2 are located only a few metres apart on the lowest slopes of Grange Hill in and just above an old obsolete field boundary.

The oldest reference to the inlier seems to be M'Coy (1846), who listed many of his species from 'the Chair of Kildare' (in the townland of Carrickanearla). This has led to much subsequent confusion since the townland includes rocks of Caradoc and Ashgill age and fossils from different horizons were treated together.

In 1858 the G.S.I. memoir to Sheet 119 (35 NE) was published (Jukes *et al.* 1858). A separate list was given for fossils found at Grange Hill House Cottage, but the identifications were not indicative of significant differences between that locality and the combination list for the Kildare Limestone and Grange Hill. These fossils have never been described although Williams *et al.* (1972) stated it was a Soudleyan fauna. Wright (1970) published a study of the inarticulate brachiopod *Orthisocrania divaricata*, which is found only in the Caradoc siltstones dated as Longvillian on the basis of faunal similarity with the Gelli-grîn Group of Bala in North Wales. Wright's list is the only modern reference to the Grange Hill (Horizons 1 & 2) fauna, which is described fully herein.

Kilbride and adjacent localities, Co. Waterford (1:126720 – SHEET 23, S578050)

The Kilbride locality is not a G.S.I. nor a Griffith locality but is one of the few recently discovered fossil sites in the area. It was found and collected first by Hilary Carlisle in the course of her doctoral research. Carlisle (1979) described the stratigraphy of the Tramore area, Co. Waterford, and listed the genera from Kilbride. Although Carlisle's work was never completed, the material she collected was largely saved by Dr D.A.T. Harper with the intention that they should jointly complete the taxonomic study of the Tramore faunas. Although the Tramore Limestone Formation collection is currently under study by Harper, Carlisle and myself, the Kilbride material was lost. Extensive re-collection of this stratigraphically significant locality in the Upper Tramore Volcanic Formation was a high priority in the present study. The locality is shown in Fig. 3 and a detailed survey of the quarry is shown in Fig. 4, which pinpoints the position from which the re-collection was made.

In Du Noyer (1865:18) four localities are listed by Baily which are adjacent to Kilbride on 1″ Sheet 179. These are Towergare (13 & 16), Munmahoge and Lisduggan (14) and Munmahoge (15), all townlands half a mile to the north of Kilbride. For all four localities the memoir descriptions are vague. Recourse to the 6″ G.S.I. fieldsheets was necessary since the localities are not even indicated on the 1″ Sheet 179. The original fieldsheets have been replaced by photographic copies in the G.S.I. and only limited information could be obtained. Munmahoge (15) was examined closely but the other localities were not traced. No fossiliferous exposures were found. However, the faunal lists are short with only three or four species other than the ubiquitous bryozoan '*Stenopora fibrosa*', although at Munmahoge (15) abundant specimens are indicated.

Ballykale, Co. Wexford (1:126720 – SHEET 19, T147570)

This locality was recorded as a G.S.I. locality (No. 9) in the Sheet 149 memoir (Hardman 1887). It was noted as being 'one mile and a half south of Gorey; tuffose rock'. The quarter Sheet 11/2 of the G.S.I. fieldsheets showed the locality, although it is possible to confuse it with any of several adjacent localities such as Coolnaveagh (No. 10), Coolnahinch (No.18), or a number of other sites indicated by asterisks on the 1″ Sheet 149, which are not easily correlated with the memoir table.

Kelly (1860) noted the locality as being '2 miles south of Gorey, on the east side of the road. The locality is nearly surrounded by a felspathic protrusion of yellow rock, such as is frequent thereabouts'. The actual position of the collection made by me is shown in Fig. 5. The locality has received no attention since the G.S.I. memoir. Field investigation did not reveal any exposure, but one large block in the base of the wall bounding the farm road was found to be packed with fossils, a nearly monospecific assemblage of *Binuria* cf. *dyfiensis* Lockley (p.155). Although not *in situ* it is believed to be of local origin. The rock is a very tuffaceous mudstone and has been relatively strongly deformed, but the flattened fossil moulds are clearly identifiable.

Clologe Upper, Co. Wexford (1:126720 – SHEET 19, T051509)

As locality 1 in the memoir for Sheet 148 (Hardman 1887), this site was also identified clearly on the G.S.I. 6″ fieldsheets, on quarter Sheet 16/1 of Co. Wexford. The memoir records that fossils came 'from debris, in a field close to the road from Norris Mount to Milltown, one mile south of Camolin; light gray and brown slates, and tuffose rock'. Re-investigation of the area, shown on Fig. 6, failed to locate

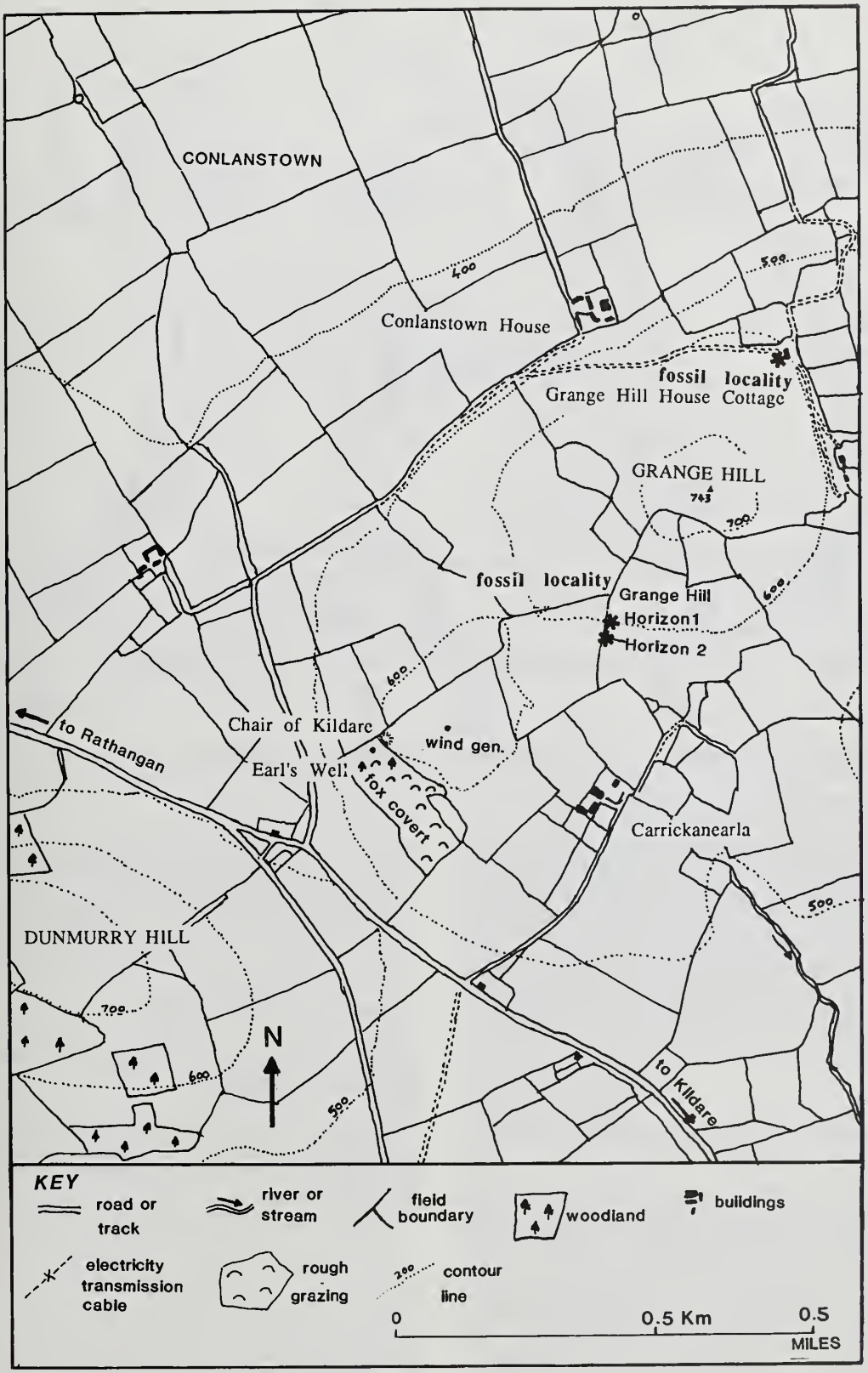

Fig. 2 Locality map of the three fossil localities in the Kildare inlier; Grange Hill House Cottage, Grange Hill Horizon 1 and Horizon 2.

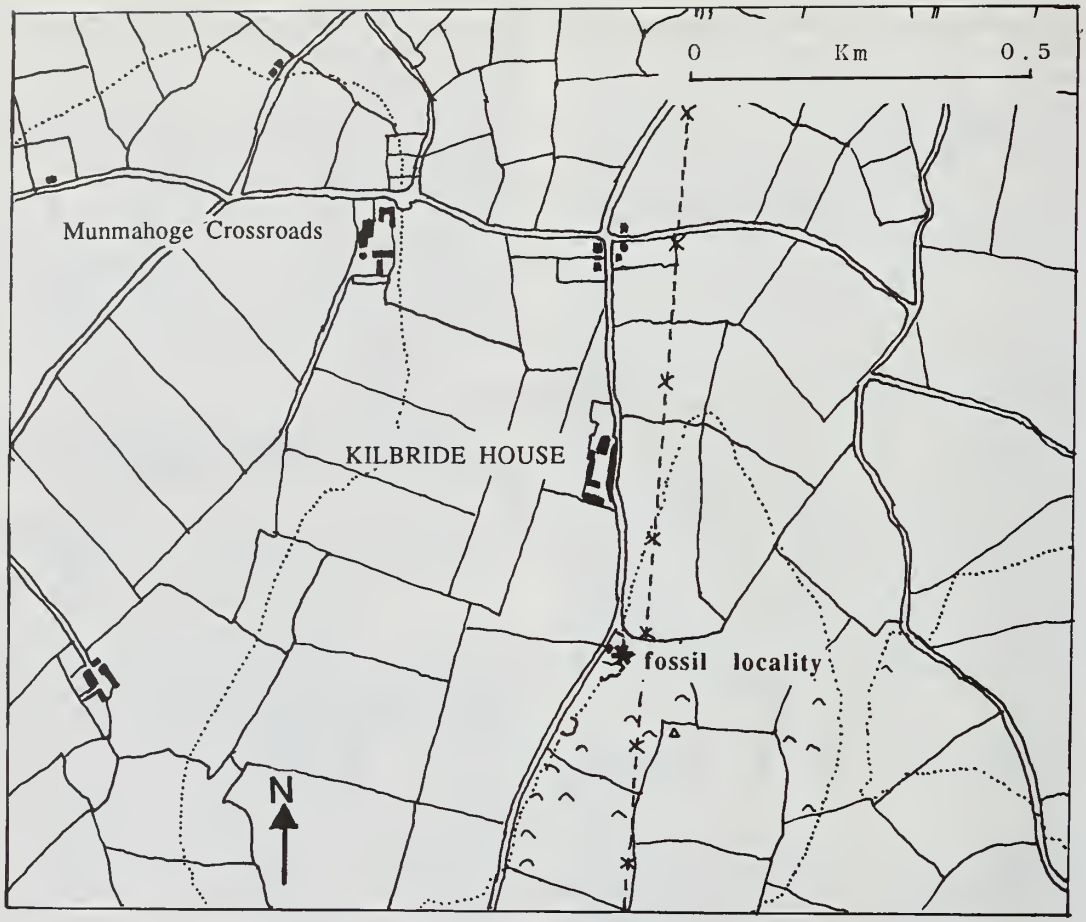

Fig. 3 Locality map of the Kilbride locality. Key as in Fig. 2.

any *in situ* exposure. However, collecting amongst loose blocks in the steep wooded slope within a restricted area yielded a large fauna comparable with that listed by Baily (*in* Hardman 1887). The fossils were found most frequently in blocks of tuff but others came from slaty siltstones and mudstones. The preservation is generally poor and identification proved difficult beyond generic level. The similarity of the fauna and lithology to that described in the memoir, and the limited section of slope where fossiliferous blocks were found, suggest that they are from the outcrop below the surface drift.

Carrigadaggan, Co. Wexford (1:126720 – SHEET 23, S313240)

Despite being one of the most fossiliferous localities in the Duncannon Group this site has received scant attention in the last 100 years. Its exact position is shown on Fig. 7. M'Coy (1846) gives this locality for many of his species – an impressive list of 16, mainly brachiopods and trilobites, but including the rhombiferan cystoid *Echinosphaerites granulatus* as an 'extremely common' element of the fauna. The faunal list given in the G.S.I. memoir (Kinahan 1879) is even more comprehensive. Thirty-eight genera are listed, again mainly brachiopods and trilobites but also several bivalve and gastropod species, as well as bryozoans, orthocones, conulariids and *Echinosphaerites aurantium* (as a very abundant species). Forbes (1848) also dealt with the locality in connection with *Echinosphaerites*. Kelly (1860) included the locality in his Wexford list and, unusually, named some species found there. Paul (1973) mentioned it, as one of 14 major cystoid localities, although no details were given. Williams *et al.* (1972:57) noted the place as a shelly locality in the Caradoc rocks of Wexford and Waterford.

Ballygarvan Bridge, Co. Wexford (1:126720 – SHEET 23, S792188)

As one of the few fossil localities in south Wexford, Ballygarvan Bridge is often mentioned in connection with Carrigadaggan, but similarly until now no systematic re-collection of the faunas has been attempted since the late 19th century. M'Coy (1846) listed 9 species; the G.S.I. memoir (Kinahan 1879) has an increased diversity of 11, but with some different species. The exact locality from which previous collections were made is in some doubt. Although the description in the memoir is characteristically imprecise, the G.S.I. 6″ field-sheets have a precisely located asterisk indicating the locality. However, the geological boundaries adjacent to the bridge itself are complex and unclear, and since there is no exposure at the indicated spot the possibility of a cartographer's mistake must be kept in mind. The present exposure is very

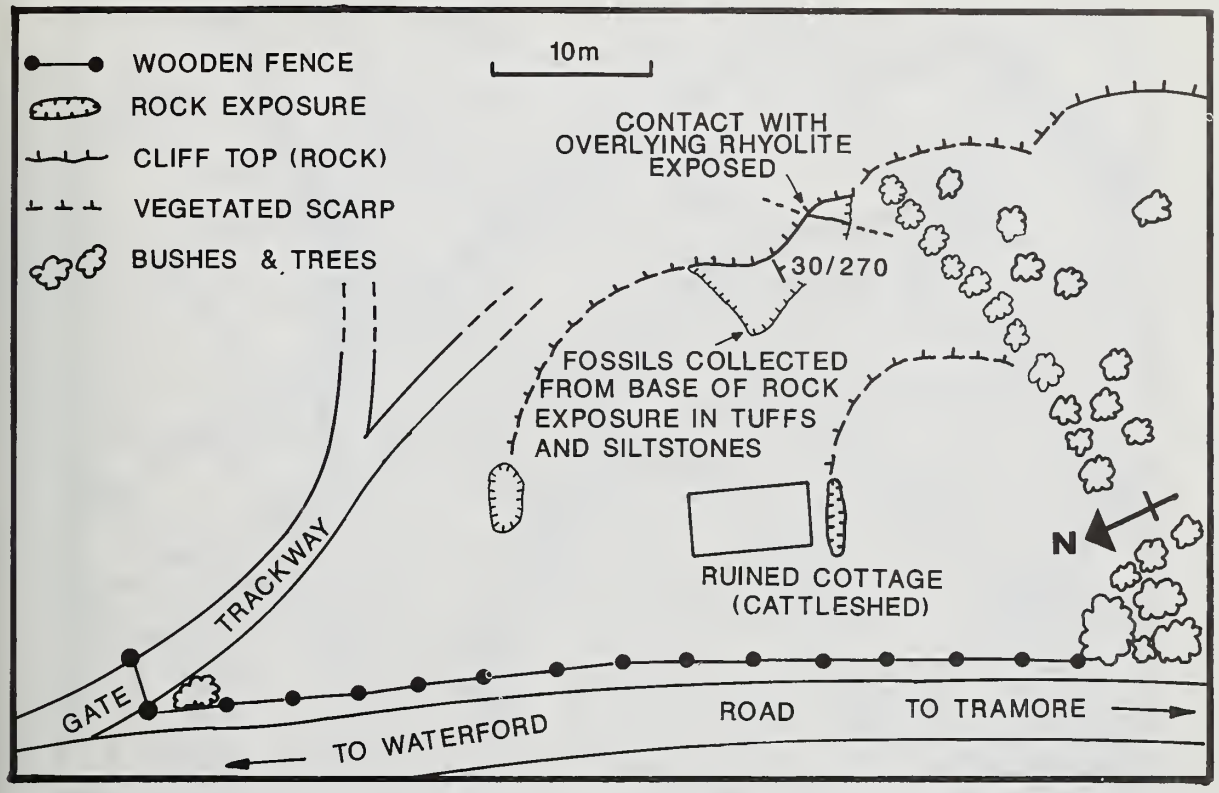

Fig. 4 Detailed plan of the Kilbride locality.

limited, but a collection was made from hard grey slates in the wooded banks of the river (see Fig. 8), approximately 20m away along the strike from the supposed locality. The fauna is sparse, although M'Coy (1846) described most elements of his list as common. All three collections were probably made from slightly different horizons in close proximity.

Frankfort and Clogh, Co. Wexford (1:126720 – SHEET 19, T109550 (Frankfort), T123555 (Clough))

These are listed by Baily (*in* Hardman 1887) as one locality. In fact the 1″ sheet 149 and the G.S.I. 6″ fieldsheets show three separate localities, all of which were investigated in the present work. No fossiliferous exposure was found at any site, although a few fossils were found in loose blocks at Clogh. The localities are the main source of fossils used to date the Ballymoney Formation of Hiller (1971) and Mitchell *et al.* (1972), although Hiller was only able to find wall blocks of fossiliferous rock, the original G.S.I. localities being infilled or overgrown. The localities are shown in Fig. 9.

Raheen, Co. Wexford (1:126720 – SHEET 23, S891326)

The original G.S.I. locality listed by Baily (*in* Kinahan 1882) for I″ Sheet 158 is an old quarry now extremely overgrown, with almost no exposure. Fortunately, during this study the local farmer had excavated a new pit roughly along the strike about 5m away from the old pit, for hardcore. On my discovery, it was already half filled with domestic refuse and is probably by now completely filled. This temporary exposure allowed collection of a large fauna. Fig. 10 shows the exact position of Raheen. The locality was not known to M'Coy (1846) or Kelly (1860), and after collection by the G.S.I. no attention was paid to it until the 1970s. Shannon (1979*a*: 46) recorded a fossil assemblage indicative of a Caradoc age. Brenchley *et al.* (1977) mentioned it in connection with specimens of *Plaesiomys*, presumably from existing collections. It is an important locality, therefore, in that it provides data along strike from better-known sections at Enniscorthy, and between there and Carrigadaggan to the southwest. It is also important in that the newly collected fauna differs somewhat from previously listed assemblages.

Greenville, Enniscorthy, Co. Wexford (1:126720 – SHEET 23, S962412)

This locality is the most important of several known from the environs of Enniscorthy. M'Coy (1846) listed many species from here, as did the G.S.I. memoir (Kinahan 1882 – locality 5). The locality was reviewed in detail by Brenchley *et al.* (1977), but it was revisited in this study, new material being collected for the sake of completeness, and with the specific aim of comparing elements of the brachiopod fauna with other sampled localities. It was also hoped to collect topotypic material of the poorly known agnostid trilobite *Trinodus agnostiformis* M'Coy, the type specimen of which was redescribed by Whittington (1950: 533). The site location is shown in Fig. 11. The rock is a very fractured buff coloured mudstone, occasionally tuffaceous. New material was excavated from shallow depth in the old farmyard, between the

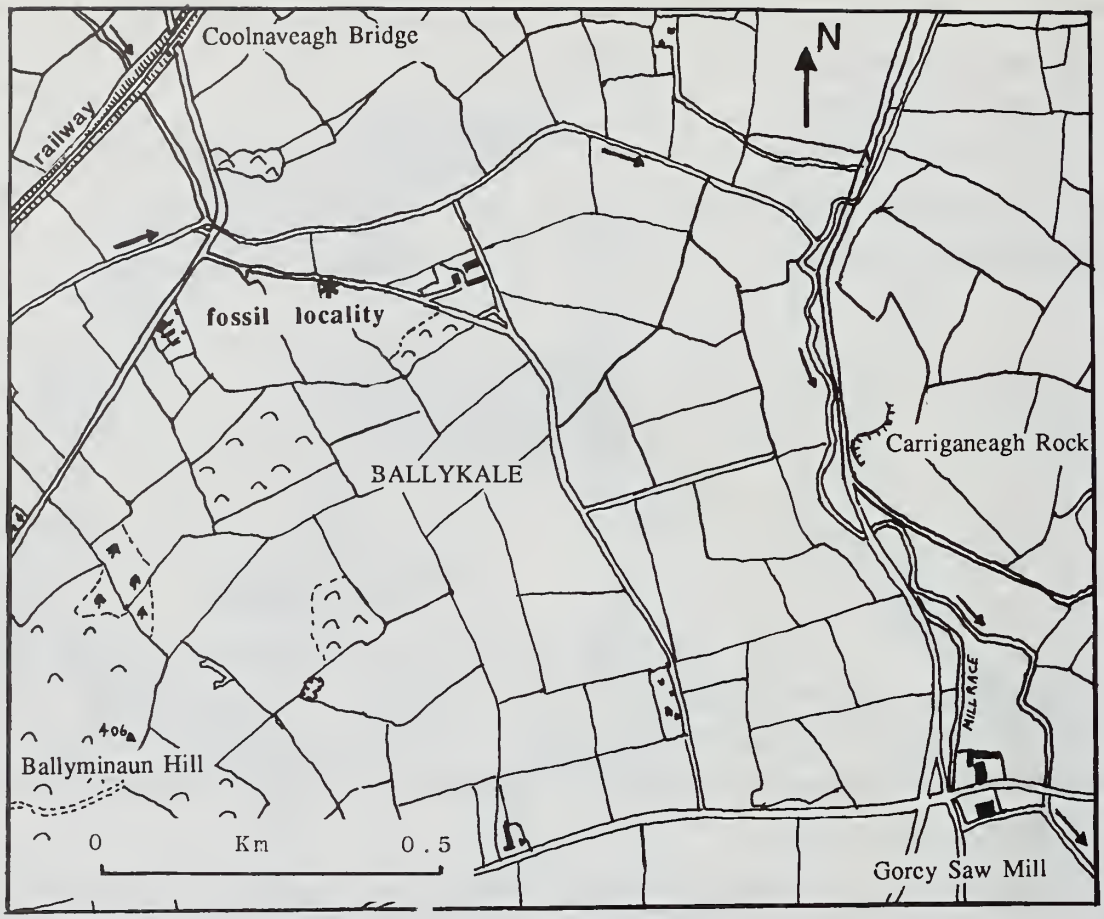

Fig. 5 Locality map of the Ballykale locality. Key as in Fig. 2.

lowest doorway of the ruined farmhouse and the new gateway to the northwest.

Greenville and Moyne Upper Boundary, Enniscorthy, Co. Wexford (1:126720 – SHEET 23, S967420)

This locality (Fig. 11) should not be confused with Greenville itself. G.S.I. locality 4 in Kinahan (1882) is Greenville and Moyne Upper Boundary, where a fauna was re-collected from many large blocks exposed as a result of very recent ploughing. These were immediately adjacent to the hedge bounding the original locality, an old quarry now slurry filled. No fossiliferous horizon was located within the exposure in the mainly volcanic quarry.

Courtown localities, Co. Wexford (1:126720 – SHEET 19, T187566 (Ballinatray)

Numerous localities in the area of Courtown are listed in an earlier section, Table 1 (p.110). These were reviewed by Crimes & Crossley (1968), Brenchley & Treagus (1970) and Mitchell *et al.* (1972). Further examination of all these localities failed, with one exception, to yield anything new or significant; fossils found were poorly preserved gastropods, a few external moulds of *Glyptorthis* and crinoid ossicles from the Courtown Formation. No new material was recovered from the Ballymoney Formation. The only exception was a collection made from calcareous slates in the Ballinatray Formation, about 160 m west of Ballinatray Bridge (Fig. 12). The present bridge is probably more recent than that named in the G.S.I. memoir (Hardman 1887), since the Courtown to Gorey road has been re-aligned since the 6″ mapping. There is considerable confusion about the exact position of localities in this area, since both the 1″ and 6″ G.S.I. maps have a profusion of fossil locality asterisks, not all of which can be related to the named localities in the G.S.I. memoir. However, both from the described position and from the fauna present it appears that this might be locality 14 of Hardman (1887), where '*Illaenus Bowmanni*', '*Leptaena sericea*' and '*Orthis calligramma*' were recorded in some abundance.

Slieveroe, Rathdrum, Co. Wicklow (1:126720 – SHEET 16, T211890)

This highly fossiliferous locality was known to Griffith's collectors (M'Coy 1846) and to the G.S.I. mapping team (Jukes & Du Noyer 1869). It was re-collected after excavation by Brenchley *et al.* (1977) and a mixed brachiopod-trilobite fauna recorded from there. Although it was re-collected by me, the combination of very strong deformation in the fragile slates and shortage of time meant that no

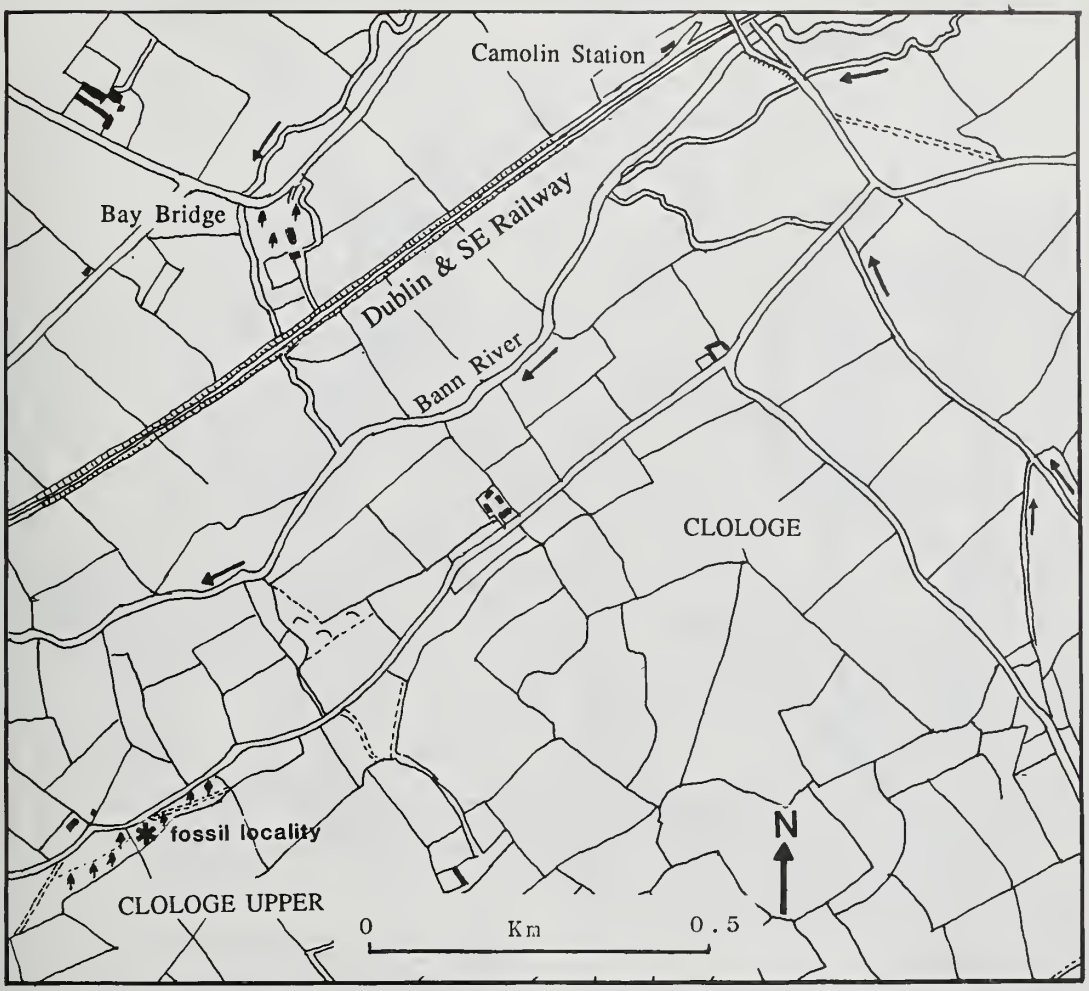

Fig. 6 Locality map of the Clologe Upper locality. Key as in Fig. 2.

further work was done on the material. The previous faunal lists are used in discussion of correlations.

Other localities

In the course of tracing the localities from the memoirs, several other records of fossils were noted. On Sheet 158 (Kinahan 1882: 26) a locality called Kellystown Bridge was described a little south of Raheen, but no details were given in the palaeontological notes and it was not traced on the G.S.I. 6″ fieldsheets nor in reconnaissance fieldwork. Kelly (1860) gave details of various localities which were not all included on the G.S.I. 6″ sheets or in the memoirs, including Ballyminaun Hill and Carriganeagh, both south of Gorey. These do not now have any fossiliferous exposure. Fossils were recorded by Shannon (1979*a*) from Raheen and Ballybrennan, both G.S.I. localities, and also from Wilton Castle southwest of Enniscorthy, but the area is now heavily forested and no fossils were found in the restricted exposure available. All other sites examined as a result of personal communications, or unnamed sites indicated by asterisks on 1″ and 6″ geological maps, proved to be either unfossiliferous or not now exposed.

METHODOLOGY AND TECHNIQUES

Sampling methods

In all sampled localities, an initial collection was made by identification of the fossiliferous lithology and on-site collection of specimens. Subsequently, the main collection of specimens was achieved by removing large volumes (between 10 kg and 80 kg, occasionally more) of the fossiliferous lithology, to be broken up and examined in a laboratory. The validity of this method was verified by the fact that successive seasons' collections served to increase the numbers of specimens, but not the diversity of the fauna. The one exception to this was the Kilbride locality near Tramore, Co. Waterford (p.112). This debris flow appears to have 'sampled' various benthic associations in its downslope movement, and subsequent collections made here increased the diversity of the fauna significantly from the initial sampling.

Fig. 7 Locality map of the Carrigadaggan locality. Key as in Fig. 2.

Preparation techniques

Standard preparation methods were used. The measurements of all material (in millimetres) were made using vernier scale calipers or a micrometric graduated microscope eyepiece, both accurate to 0·1 mm. The combination of camera, lenses and extension rings (Table 5) gave a range of magnifications of up to X5. The specimens were whitened with ammonium chloride sublimate before being photographed.

Taxonomy and statistical analysis

In this study both multivariate and bivariate analyses have been utilized where the measurement data were adequate.

Table 5 Magnifications obtained by different lens and extension ring combinations.

AF Micro-Nikkor 55 mm f/28	×1
AF Micro-Nikkor 55 mm f/2·8, PK11A, PK12, PK13	×2
24 mm lens reversed + PK11A	×3
24 mm lens reversed + PK13	×4
24 mm lens reversed + PK11A + PK12 + PK13	×5

NOTE: All other combinations produce non-integer magnifications. Magnification less than X1 necessitated the use of the AF Micro Nikkor 55 mm, but not fully extended. The magnification was calculated by comparison of the negative with the measured specimen size.

For detailed discussion of statistical methodology in brachiopod systematic work, reference can be made to Williams (1962), Harper (1984) and Temple (1987). In many older palaeontological references the use of statistics to define species is minimal or non-existent. For example, the fundamental work of M'Coy (1846) quotes the length of most species described as a single value (in inches and lines, where a line = $1/12^{th}$ of an inch). No indication is given as to whether this is the length of a figured specimen or a subjective assessment of the mean length of a sample. Here a pragmatic approach was taken, and measurements were made on any specimens worth measuring. Some measurements taken on slightly deformed material are included in descriptions in the text as a guide to proportions, but where this occurs it is pointed out. Table 6 is a set of defined variates as used by Harper (1984) and adhered to in the present work. Although in some cases the measurements taken did not provide sufficient reason to classify a sample as belonging to a particular species, the original data for these and all measured specimens is lodged in the General Library Biological Data Collection at The Natural History Museum, South Kensington, London. The figured specimens themselves are deposited in the Palaeontology Department collections there, register number prefix BC. Another set of the data is lodged in the James Mitchell Museum, University College, Galway, where all non-figured brachiopods and other material are deposited. Analysis was done using the 'Palstat' package on BBC microcomputers (Harper & Ryan 1987).

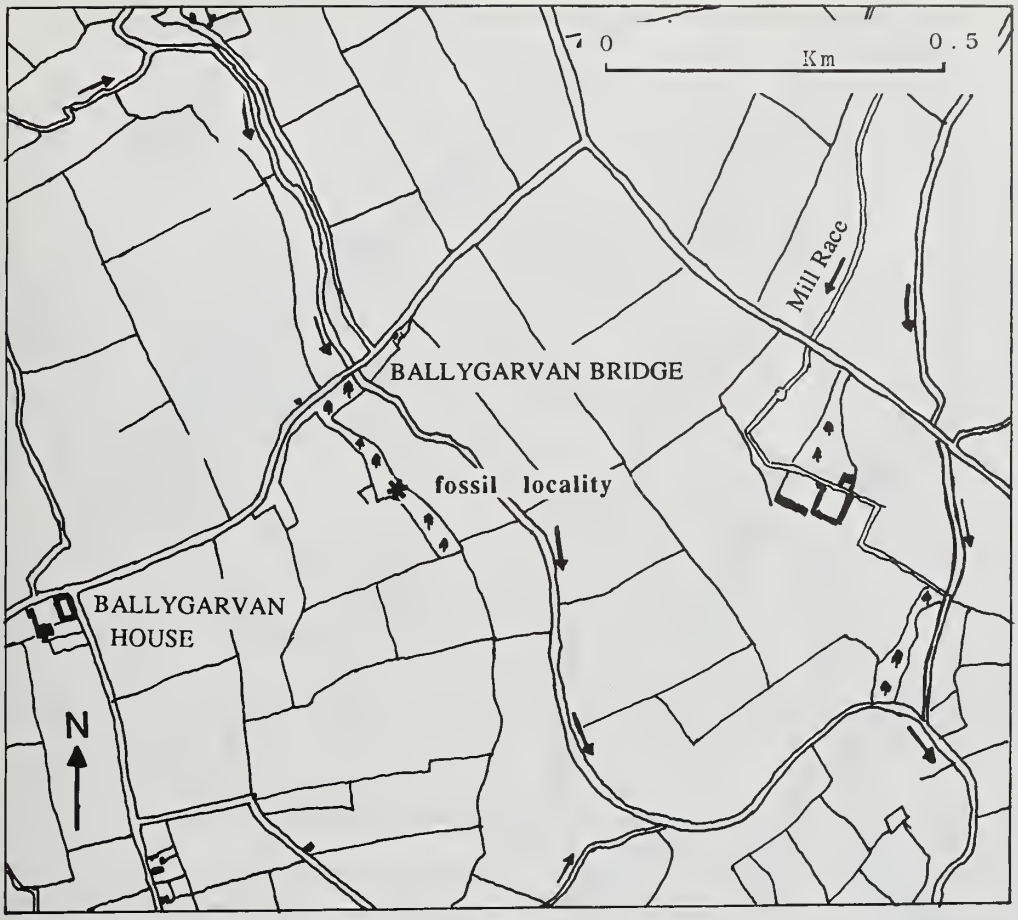

Fig. 8 Locality map of the Ballygarvan Bridge locality. Key as in Fig. 2.

STRATIGRAPHICAL CORRELATION

The stratigraphy of SE Ireland, as presently understood, is the result of many years work by innumerable individuals. The present study is concerned only with one part of the succession – the Duncannon Group, which is a mid-Upper Ordovician (mainly Caradoc) volcanic-dominated sequence, with clastic sedimentary intercalations. It is generally unconformable on the Lower Ordovician (Arenig – Llanvirn/Llandeilo?) Ribband Group.

In certain better-exposed areas, notably Courtown (Brenchley & Treagus 1970, Mitchell *et al.* 1972) and Tramore (Stillman 1976, Carlisle 1979), more detailed stratigraphies have been erected with several local formations. The two areas of Courtown and Tramore were correlated on the basis of faunas and comparable stratigraphies by Mitchell *et al.* (1972), and the age subsequently revised by Carlisle (1979) through better knowledge of the extent of the *gracilis* Zone. Thus both the lowest calcareous horizons, the Tramore Limestone Formation and the Courtown Formation, are considered as late Llandeilo in age, or even older (Llanvirn-Llandeilo) based on conodonts (Bergström 1971).

The thick development of volcanics west of Tramore and Waterford is perhaps the most complex area of the Duncannon Group and there is much debate as to the true sequence there. Tietzsch–Tyler (1989) reviews the various arguments and draws his own interpretations for the G.S.I. compilation maps used in Parkes (1990). Stillman (1976) has noted that the succession is subdivided on lithostratigraphical grounds and should be regarded as comprising 'volcanogenic units', essentially derived from a volcanic centre situated about 4 km northwest of Tramore, and another farther west. The importance of fossil assemblages to date horizons within such sequences is thus clear, to confirm and supplement the petrological and field relationships of the units. The Tramore Limestone Formation and some *gracilis*-bearing shales were the only well-dated horizons until Carlisle (1979) recorded a shelly assemblage from Kilbride, which is described herein (Table 11, p.129). The assemblage, near the top of the succession, provides some constraint on the date of cessation of volcanism in Waterford. Consequently, although the age of the Kilbride fauna is discussed below, the remainder of the sequence and its faunas underlying the Kilbride assemblage is outside the scope of this review, as previously noted.

Re-examination of the Courtown localities collected by Crimes & Crossley (1968), Hiller (1971), Brenchley & Treagus (1970) and Mitchell *et al.* (1972) yielded no significant new information and the formations erected by these authors and the existing age constraints described from the fossil assemblages are thus accepted here. The development of

Fig. 9 Locality map of the Frankfort and Clogh localities. Key as in Fig. 2.

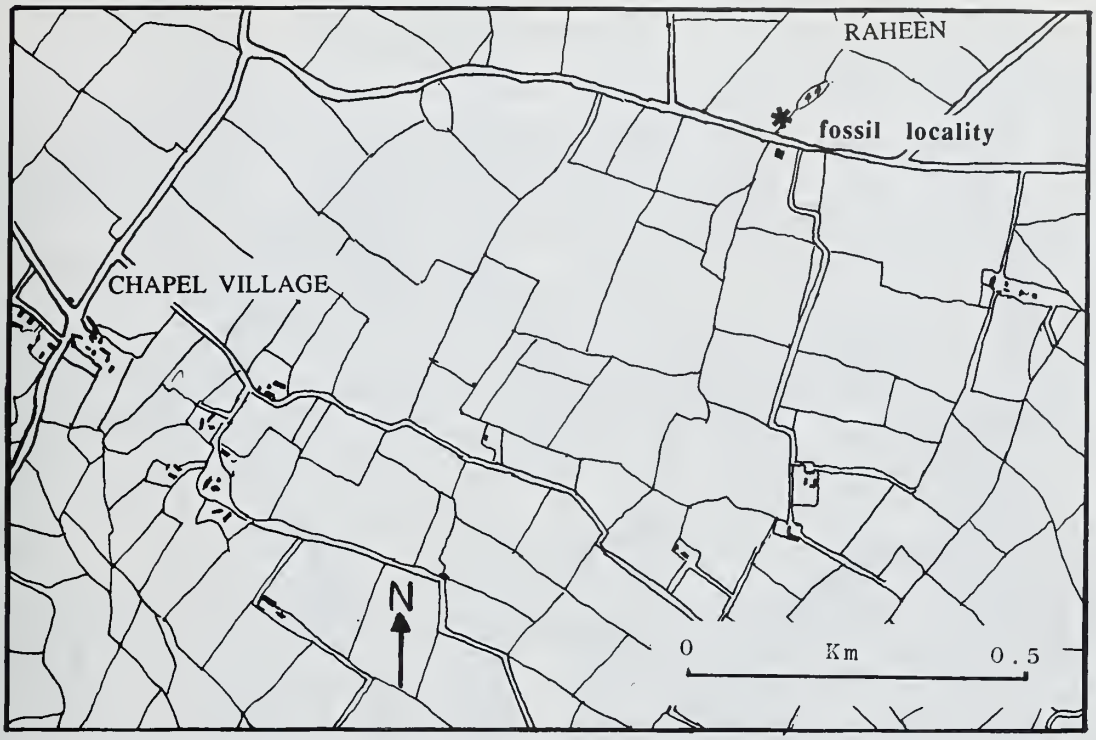

Fig. 10 Locality map of the Raheen locality. Key as in Fig. 2.

Table 6 Definition of variates measured on the fossil brachiopods in this paper.

X1	sagittal length
X2	maximum width
X3	position of maximum width measured from posterior margin
X4	maximum depth measured perpendicular to sagittal length
X5	hinge width
X6	maximum length of interarea
X7	origin of fold or sulcus measured from posterior sagittal margin
X8	maximum width of rim or limbus
X9	maximum length of muscle scar measured from posterior sagittal margin
X10	maximum width of muscle scar
X11	wavelength of median rib at 5 mm growth stage
X12	position of apex measured anteriorly from posterior margin
X13	length of base of spondylium
X14	maximum width of spondylium
X15	length of base of cruralium
X16	maximum width of cruralium
X17	anterior extension of brachiophore bases measured from umbo in plane of sagittal length
X18	transverse separation of ends in brachiophore bases
X19	maximum depth of sulcus
X20	maximum width of sulcus
X21	length of cardinal process base
X22	sagittal length of submedian septa
X23	transverse separation of anterior ends of submedian septa
X24	sagittal length of median septum

calcareous clastics followed by black graptolitic shales within *gracilis* times appears to have been restricted to the areas mentioned above, since no comparable sequence is recognized elsewhere in the Duncannon Group, and has not been found in boreholes.

In between these two areas, the main belt of Duncannon Group rocks is poorly exposed, often as resistant hills of rhyolitic intrusions or thicker volcanic units which were probably original volcanic centres. The succession is poorly differentiated, despite several intensive studies. The Duncannon Group was defined by Gardiner (1974) from the Duncannon district of southwest Wexford and divided into four formations; Duncannon Volcanic Formation, Arthurstown Formation, Ballyhack Formation and Campile Volcanic Formation, all of Caradoc age based on graptolite evidence, in the regional Campile Syncline (Gardiner 1970). However, Shannon (1978, 1979*a*), in mapping the area south of Enniscorthy, but not continuous with the area of Gardiner (1967), differentiated the succession into only two Formations: the Doonooney Formation (with the Ballybrennan Volcanic Member) and the younger Raheenahoon Volcanic Formation, which encompasses the main rhyolitic volcanism. Both Raheen and Carrigadaggan are within the latter formation in the area mapped by Shannon. The remapping of mid Co. Wexford (Geraghty 1989) north of Shannon's area has confirmed the threefold division into Cahore, Ribband and Duncannon Groups.

Despite the poor exposure and limited extent of the inlier at Kildare, the sedimentary succession is more varied and the palaeontological constraints on the age of different horizons is better understood, although there are many problems remaining. The Duncannon Group equivalents probably lie unconformably upon the older rocks below them. A Soudleyan fauna and a Longvillian fauna constrain the age of volcanism here, being found above and below the lavas of Grange Hill. There are Ashgill faunas in the Kildare Lime-

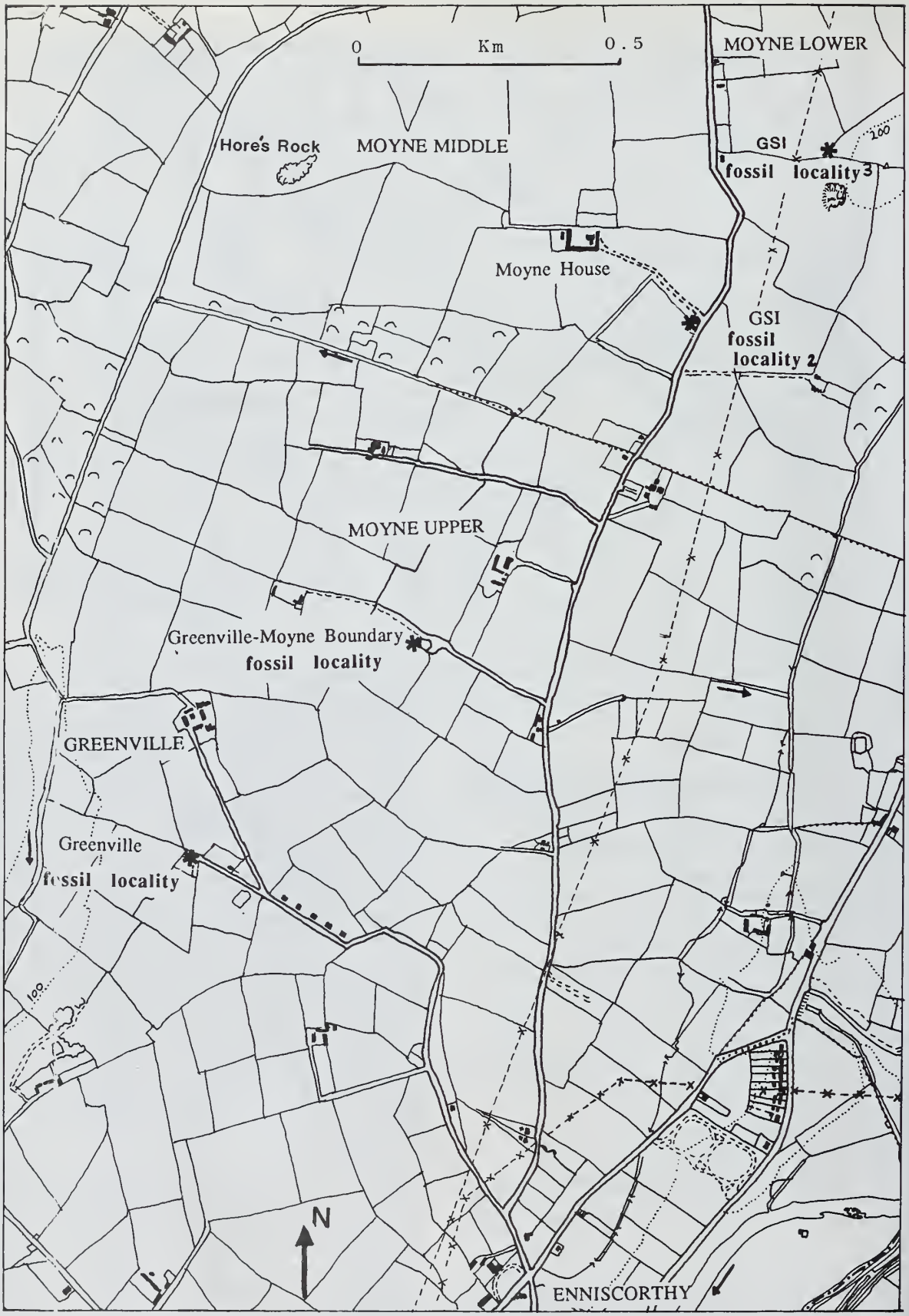

Fig. 11 Locality map of the Greenville and Greenville-Moyne Boundary localities and now unexposed G.S.I. localities at Enniscorthy. Key as in Fig. 2.

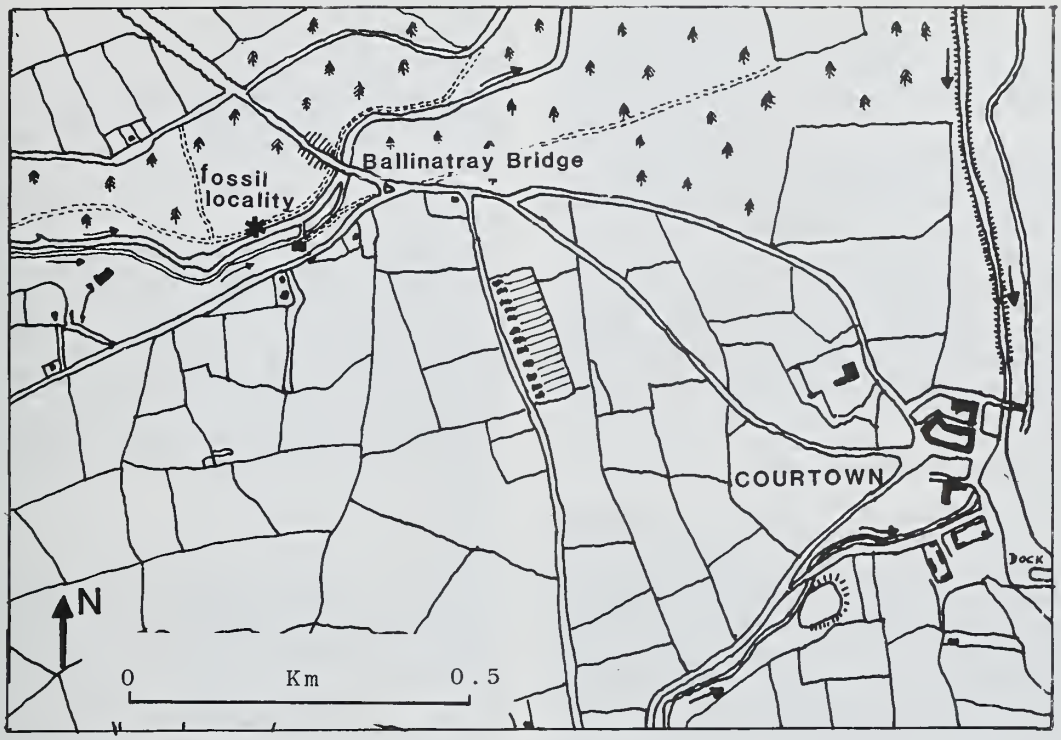

Fig. 12 Locality map of the Ballinatray locality. Key as in Fig. 2.

stone Formation (Rawtheyan) and the well known *Hirnantia* fauna in the topmost mudstones. A review of this inlier is given by Parkes & Palmer (1994). The stratigraphy of the eastern Ireland successions in the Iapetus suture zone has been investigated by Murphy (1987), who identified two separate terranes, the Grangegeeth and Bellewstown terranes, between the Balbriggan-Herbertstown sector of the Leinster terrane and the Central terrane (equivalent of the Southern Uplands of Scotland). These terranes are identified on the basis of contrasting volcanic characteristics and stratigraphical sequences as well as faunal differences. Murphy (1987) also correlated the sequences of eastern Ireland with those of the Leinster terrane and the Lake District of England.

Within the Leinster terrane, recent detailed reviews of the complete stratigraphical successions have been by Williams *et al.* (1972), Brück *et al.* (1978, 1979), and Holland (1981). More recently Harper & Parkes (1989) summarized the palaeontological constraintson the development of Irish Caledonide terranes, a subject expanded upon in Murphy *et al.* (1991). Parkes & Vaughan (1992) and Owen *et al.* (1992) have dealt specifically with the Grangegeeth terrane.

Tietzsch-Tyler (1989) has completed a re-evaluation of the Lower Palaeozoic geology, as well as the preparation of G.S.I. compilation maps, for south-east Ireland. This latter work involves numerous modifications which are outside the scope of the present work, but several redefined formations are used in the Duncannon Group, as explained in the key to those maps. Principal of these is the Annestown Formation, of essentially rhyolitic composition with andesite, slate and limestone members. This represents undifferentiated middle Duncannon Group sediments and volcanics on the map, and is the equivalent of the Doonooney and Raheenahoon Volcanic Formations of Shannon (1978). It is also equivalent to the Lower Tramore Volcanic Formation and all formations above (except the intrusive rhyolites in the Upper Tramore Volcanic Formation of Carlisle (1979)), the Duncannon, Arthurstown, Ballyhack and Campile formations of Gardiner (1974), and the Ballymoney and Gorey Rhyolite formations of Brenchley & Treagus (1970), as well as the Upper Caradoc Raheen Formation of Owen *et al.* (1986). Tietzsch-Tyler's Carrighalia Formation (equivalent to the Ross and Loftusacre Formations) with its Tramore Limestone Member is also the equivalent of the Courtown and Ballinatray formations of Brenchley & Treagus (1970).

AGE OF THE ASSEMBLAGES

Kildare, Grange Hill, Horizons 1 and 2

Wright (1970) claimed that these were Longvillian in age, on the grounds that their composition is similar to assemblages from the Gelli-grîn Formation of the Bala district of Wales, and in particular in relation to the presence of the calcareous inarticulate *Orthisocrania divaricata*, whose occurrence could only be substantiated in Longvillian rocks in Britain.

Whilst there are some differences noted (Tables 8, 9, p.128) between the assemblage described herein and that listed by Wright (1970), in essence the fauna still shows a strong affinity with the Welsh Bala faunas described by Williams (1963). Many of the genera are long-ranging in the Caradoc, or even the Ordovician, and where samples are inadequate to determine the species, then the overall generic composition has been used. However, at Grange Hill both

Orthisocrania divaricata and *Cremnorthis parva* occur, and these are at present only known from Longvillian rocks in Britain. *Leptestiina oepiki* is also recorded first in Longvillian Welsh localities (Williams 1963). Although *Cremnorthis* (Hints 1968, Llandeilo) and *Orthisocrania* (see p.136) are known from older Baltic successions and may have migrated to Leinster at a time different from their Welsh Basin arrival, on balance, with the total assemblage affinities with the Gelli-grîn Formation, a Longvillian age is most likely for this assemblage.

Given the close relationship of Grange Hill Horizon 2 to Horizon 1 with a substantially similar but reduced diversity assemblage, a similar Longvillian age is suggested for this horizon also. The position of the various localities at Kildare in the stratigraphical succession of the inlier is schematically illustrated in Fig. 13.

Kildare, Grange Hill House Cottage

The only modern reference to the faunal assemblage from this locality is Williams *et al.* (1972). A Soudleyan age is claimed for the fauna, presumably on the basis of comparisons with the faunal list published by Reynolds & Gardiner (1896). The recollection of the fauna, as described herein, confirms that suggested age. The palaeoecology of this assemblage differs substantially from other Duncannon Group faunas described here (Table 10, p.129), but the brachiopod species show a strong similarity with a fauna from Herbertstown, in the northernmost part of the Leinster terrane, described by Harper *et al.* (1985). The combination of *Plaesiomys multiplicata* and *Oanduporella* cf. *reticulata* is unknown elsewhere in the Leinster terrane (except possibly at Clologe Upper). Indeed, the enteletoidean *Oanduporella* was unknown outside the Baltic before the Herbertstown record. The assemblage at Herbertstown was noted as being unlike any other fauna recorded in eastern Ireland (Harper *et al.* 1985: 289), but the new Kildare sample shows strong resemblances. On balance, the Herbertstown fauna was restricted to the Caradoc, with a most probable Soudleyan age. Similarly at Kildare, the fauna cannot be younger than Longvillian since it lies below the andesites of Grange Hill, which themselves are below a Longvillian assemblage. On the whole a Soudleyan age is most likely since the common brachiopod *Plaesiomys multiplicata* is found in the Soudleyan of Glyn Ceiriog of North Wales (Bancroft 1945) in association with *Rafinesquina*, which is present at Kildare too. The relationship of this horizon to others at Kildare is shown in Fig. 13.

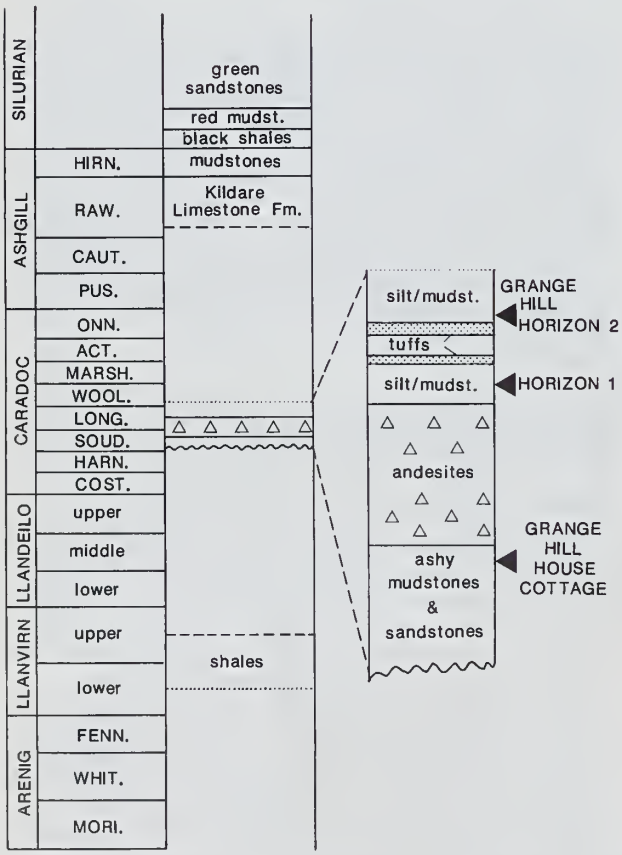

Fig. 13 Schematic section of the succession in the Kildare inlier.

Kilbride

At this locality Carlisle (1979) listed a fauna with some forms congeneric with those in the fauna described here (Table 11, p.129). There are several differences, but the principal genera are all indicative of a Caradoc age. Carlisle (1979: 552) recorded *Decordinaspis*, a trinucleid trilobite previously only found in the Harnagian/Soudleyan of Grangegeeth (Harper & Romano 1967). Thus she suggested a Soudleyan age for the base of the Upper Tramore Volcanic Formation, in which Kilbride is located, with an unknown upper limit but possibly extending into the Upper Caradoc. This author did not identify *Decordinaspis* here, but, based on the co-occurrence of *Cremnorthis parva*, *Leptestiina oepiki* and *Sowerbyella sericea*, a Longvillian age is postulated for the assemblage. This accords well with Carlisle's interpretation. If the *Orthisocrania* she recorded proves to be *O. divaricata*, this would further enhance the reliability of the age assigned, since the locality was said (Carlisle 1979: 551) to be 200 m above the base of the formation.

Ballykale

This assemblage is relatively low in both specimen numbers and diversity, being dominated by *Bimuria* cf. *dyfiensis* (81%, see Table 12, p.130). This species has only been described previously from the Gelli-grîn Formation of north Wales (Lockley 1980:215), which is of Longvillian age. In the other localities dealt with here, *Bimuria* sp. definitely occurs only at Kilbride, in a form probably conspecific or at least very close to *B.* cf. *dyfiensis*. This locality too is of probable Longvillian age and this seems the most reasonable estimate for the age of the Ballykale assemblage also. The few other brachiopods are all congeneric with Kilbride forms, notably the rare *Ptychoglyptus*.

Clologe Upper

Since the poor preservation of fossils from here permitted only a generic level identification at best, the precision of correlation can only be crude. Overall, the generic composition indicates a Caradoc age and some strong similarities with the other assemblages described herein. However, the possible occurrence of both *Oanduporella* and *Plaesiomys*, both

reminiscent of the Soudleyan fauna at Grange Hill House Cottage, Kildare and the Soudleyan Herbertstown assemblage (Harper *et al.* 1985), together with the apparent absence of *Cremnorthis* and *Orthisocrania,* suggest that the assemblage is older than Longvillian. Therefore, a probable Soudleyan, or perhaps Harnagian, age is postulated.

Carrigadaggan

The brachiopod fauna contains numerous elements which allow confident assignment of the assemblage to the Longvillian, and enhance the strong inter-locality correlation. *Leptestiina oepiki, Cremnorthis parva, Orthisocrania divaricata, Sowerbyella sericea, Skenidioides costatus* and *Kullervo* aff. *hibernica* are all found in the Longvillian of Grange Hill, Kildare, as are many of the genera such as *Nicolella*, *Platystrophia* and '*Orthambonites*'. The species listed above, except *Orthisocrania* and *Kullervo,* are here recorded at Kilbride also (Table 14, p.131); Carlisle (1979) also listed *Orthisocrania* from there. The presence of *Saukrodictya* sp. is noted here, which although rare, also occurs at Kilbride, Ballykale and Greenville-Moyne, all of which are probably of Longvillian age. The cystoid *Echinosphaerites* cf. *granulatus* is most common here, but was also found at Kilbride and Ballygarvan Bridge. Although not stratigraphically useful, its occurrence in these three geographically close localities is supportive of the brachiopod correlation.

Ballygarvan Bridge

The sparse brachiopods from this locality allow little certainty about correlation of the assemblage, neither does the restricted trilobite material. The generic composition and abundance of gastropods (Table 15, p.131) is notably similar to that of Grange Hill (Table 8, p.128) and Grange Hill House Cottage (Table 9, p.128) at Kildare. This may be merely ecological control. However, as the large inarticulate *Lingulella ovata* occurs elsewhere in Leinster only in the Longvillian of Grange Hill, Kildare, a possible Longvillian age is suggested. In spite of the low numbers of specimens, the congeneric forms enhance the consistency of inter-locality correlation in the Duncannon Group.

Frankfort and Clogh

The examination of these localities was unproductive for new assemblages. However, the collections made by N. Hiller (for a B.Sc. thesis, 1971) and subsequent publication (Mitchell *et al.* 1972) correlating the Courtown area with the Tramore region, and now housed in the Ulster Museum in Belfast, were examined for comparison with other collections made in the present study. The list of genera published by Mitchell *et al.* (1972) is quite long but does not reflect the proportions within the assemblage. The strong deformation and poor preservation in the tuffaceous rocks, collected from walls in the area of the G.S.I. locality, made unequivocal identifications difficult. Many genera are represented by one questionable specimen only. The abundant genera are *Cremnorthis*, '*Orthambonites*', *Leptestiina* and dalmanelloids. Less common but positively present are *Kullervo, Platystrophia, Anisopleurella, Skenidioides, Nicolella* and *Orthisocrania*. The apparent absence of some of the other listed genera could be due to incomplete donation of the collection, rather than absence from the assemblage, since not all specimens were clearly labelled. The particular elements not seen in the material at the Ulster Museum were *Diambonia, Ptychoglyptus, Eoplectodonta, Pseudolingula* and *Actinomena*? The *Christiania* recorded is a somewhat equivocal single specimen which is highly strained.

Thus, if the definitely present and abundant elements alone are considered, the assemblage clearly takes on a strong resemblance to the described assemblages from Grange Hill, Carrigadaggan, Greenville-Moyne and other localities in Wexford. The re-examination of this assemblage, in conjunction with a revision of the Duncannon Group localities throughout Wexford and elsewhere in the Leinster terrane, reinforces the Upper Soudleyan – Longvillian age assigned to the Ballymoney Formation by Carlisle (1979: 552; fig. 3). On the basis of the existing brachiopod collections this will not be refined further, but new material or the current examination of the trilobite collections in the G.S.I. may yield better information.

Raheen

The assemblage described here (Table 16, p.131) is clearly inadequate for a confident correlation and is probably facies controlled, rather than of different age from other localities in the Duncannon Group. When the trilobite identification is complete a better constraint on the age might be made, but in the absence of better material the G.S.I. lists (Kinahan 1882) give a good indication of the age of adjacent beds in the succession. There are no species known to be restricted temporally, but typical Longvillian genera are absent. Some elements are reminiscent both of Greenville and the Brickworks Quarry Shale Formation of Grangegeeth (Romano 1980*a*), which are believed to be Harnagian or Soudleyan. Therefore, an early Caradoc age, possibly Harnagian or Soudleyan, is thought to be the best estimate.

Greenville

The collections made here (Table 17, p.132) are somewhat reduced by comparison with those of Brenchley *et al.* (1977). These authors suggested a Harnagian age, and no significant evidence has been found to dispute that in the assemblage described here. Only the probable occurrence of *Oandu porella*, present in the Soudleyan of Herbertstown (Harper *et al.* 1985) and in the Soudleyan assemblage at Grange Hill House Cottage, Kildare, suggests a possible Soudleyan age. Brenchley *et al.* (1977) attached some significance to the presence of 'an early species of *Sericoidea* together with *Anisopleurella* aff. *multiseptata* Williams'. As discussed in the systematic description of *Chonetoidea* (the senior synonym of *Sericoidea*), the variation amongst the population is considerable and assignment to *C.* aff. *abdita* Williams would now only suggest a Lower Caradoc age. *Anisopleurella multiseptata*, described from the Costonian Derfel Limestone Formation (Whittington & Williams 1955), is known also from the Longvillian Gelli-grîn Formation of Bala, North Wales (Lockley 1980).

Greenville-Moyne

Several elements, such as *Cremnorthis parva, Leptestiina oepiki* and *Skenidioides costatus,* are conspecific with samples from Longvillian assemblages at Kilbride, Carrigadaggan and Grange Hill Horizon 1 at Kildare. Other forms only identifi-

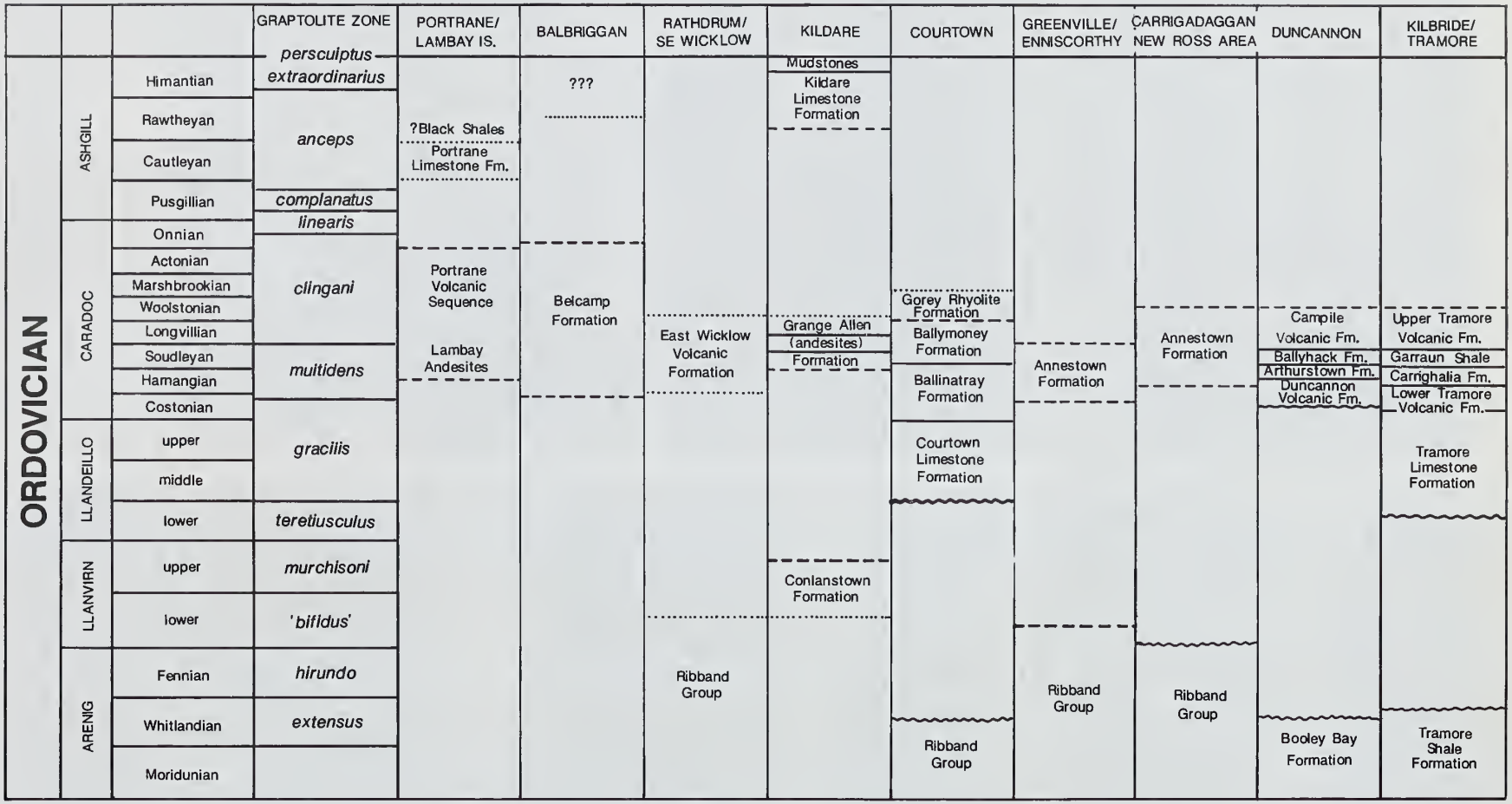

Fig. 14 Stratigraphical correlation chart for selected localities within the Leinster terrane of SE Ireland. *Sources*: Lambay/Portrane: various including Williams *et al.* 1972, Murphy 1987. Balbriggan: Murphy 1987. Rathdrum/SE Wicklow: Brück *et al.* 1979. Kildare: Williams *et al.* 1972, this study. Courtown: Carlisle 1979, Brenchley & Treagus 1970. Greenville/Enniscorthy: Brenchley & Treagus 1970, this study. Carrigadaggan/New Ross Area: this study, Tietzsch-Tyler 1989. Duncannon: Carlisle 1979. Kilbride/Tramore: this study, Carlisle 1979.

able generically or questionably assigned, e.g. *Nicolella* sp., '*Orthambonites*' sp., *Orthisocrania*?, *Rhactorthis*? and *Sowerbyella*?, are all reminiscent of those assemblages, as is the rare occurrence of *Saukrodictya* sp. *Kullervo* aff. *hibernica* is also present at Greenville-Moyne, Carrigadaggan and Grange Hill Horizon 1, all localities thought to be Longvillian in age, but it also occurs in the Knockerk House Sandstone Member (Romano 1980*a*) of the Grangegeeth Group (equivalent to the Upper Tuffs and Shales of Harper, 1952), which is believed to be Costonian in age (Brenchley *et al.* 1977). However, the consistency of the inter-locality correlations suggest that a Longvillian age is most probable for the Greenville-Moyne assemblage.

Ballinatray

Although the assemblage from here is too deformed and broken to identify the brachiopods precisely, the age of the horizon is constrained by previous work. The age of the older Courtown Limestone Formation is believed to be mainly Llandeilo ranging up to the Costonian Stage of the Caradoc on the correlation with the Tramore Limestone Formation (Carlisle 1979). The succeeding Ballymoney Formation is believed to be of probable Longvillian age, and in any case *gracilis* Biozone graptolites have been recovered from the Ballinatray Formation (Mitchell *et al.* 1972). An early Caradoc, at least partly Costonian age is suggested for the formation.

In the light of the age constraints clarified by a revision of these Duncannon Group faunas a revised correlation chart has been produced (Fig. 14), with sections additional to previously published correlations e.g. Williams *et al.* (1972) and Brück *et al.* (1979).

PALAEOECOLOGY AND BIOGEOGRAPHY

In some of the localities very little ecological data can be derived because the exposures were small, resricted and isolated from a clearly defined succession, or assemblages were not from *in situ* rocks. Equally, small assemblages like those from Ballygarvan Bridge (Table 15) are inadequate for detailed interpretation. Even with large assemblages such as Grange Hill Horizon 1 (N=646) some reservations are held about interpreting too much from them.

One evident point from this work is that assemblages often differ from previously recorded collections, especially those of M'Coy (1846) and the G.S.I. Memoirs. Many differences are simply taxonomic artefacts reflecting better systematic differentiation of this important phylum. Where the outstanding differences are not addressed directly below, the best explanation is that in the volcano-sedimentary setting of these localities the character of faunas changed as a result of tuff falls etc. and slightly different horizons have been sampled. This would apply to Ballygarvan Bridge, Raheen, Greenville and possibly Greenville-Moyne for example.

For each locality a table of the total collected fauna is presented. Table 7, however, is a summary chart of presence/absence data for each locality, highlighting the inter-locality affinities. The tables (8–19) include total counts of the brachiopod valves and various animals for the comparison of assemblages with recognised palaeocommunities discussed below. Following Lockley (1980: 171) this number has been

Table 7 Summary chart of fauna collected at each locality. Localities: A – Kildare, Grange Hill Horizon 1. B – Kildare, Grange Hill Horizon 2. C – Kildare, Grange Hill House Cottage. D – Kilbride. E – Ballykale. F – Clologe Upper. G – Carrigadaggan. H – Ballygarvan Bridge. I – Raheen. J – Greenville. K – Greenville-Moyne. L – Ballinatray.

	A	B	C	D	E	F	G	H	I	J	K	L
BRACHIOPODS												
Acanthocrania?	●	–	–	●	–	–	–		–	–	–	–
Anisopleurella cf. *multi-septata*	–	–	–	●	–	●	–	–	–	–	●	–
Bicuspina?	–	–	–	●	–	–	●	–	–	–	–	–
Bimuria cf. *dyfiensis*	–	–	–	–	●	–	–	–	–	●	●	–
Bimuria sp.	–	–	–	●	–	–	●	–	–	●	●	–
Chonetoidea abdita	●	–	–	●	●	–	–	–	●	●	–	●
Cremnorthis parva	●	–	–	●	–	–	●	–	–	–	●	–
dalmanellids indet.	●	●	●	●	●	●	●	●	●	●	●	●
Dolerothis?	–	–	●	–	–	●	●	–	–	–	●	●
Glyptorthis	–	–	–	–	–	●	●	–	–	–	–	–
Hedstroemina sp.	●	●	–	–	–	–	–	–	–	–	–	–
Hesperorthis sp.	–	–	–	●	–	–	–	–	–	–	–	–
Hibernodonta?	–	–	●	–	–	–	–	–	–	–	–	–
Kjaerina?	–	–	–	–	–	●	–	–	–	–	–	–
Kjerulfina?	●	–	–	–	–	–	–	–	–	–	–	–
Kullervo aff. *hibernica*	●	–	–	–	–	–	●	–	–	–	●	–
Leptaena sp.	●	●	●	–	–	–	–	–	–	–	–	–
Leptellina cf. *llandeiloensis*	–	–	–	–	–	–	●	–	–	–	–	–
Leptestiina oepiki	●	–	–	●	●	●	–	–	–	–	●	●
Leptestiina oepiki ampla	–	–	–	–	–	–	●	–	–	–	–	–
Lingulella ovata	●	●	–	–	–	–	–	●	–	–	–	–
Nicolella cf. *actoniae*	●	–	–	●	–	●	●	●	–	–	●	–
Oanduporella cf. *reticulata*	–	–	●	–	–	●	–	–	–	●	–	–
'*Orthambonites*' sp.	●	–	–	●	–	–	●	–	–	–	●	–
Orthisocrania divaricata	●	●	–	–	–	–	●	–	–	–	●	–
Oxoplecia?	–	–	–	–	–	–	●	–	–	–	–	–
Petrocrania harperi	●	●	●	–	–	–	–	–	–	–	–	–
Philhedra sp.	●	–	–	–	–	–	–	–	–	–	–	–
Plaesiomys multiplicata	–	–	●	–	–	●	–	–	–	–	–	–
Platystrophia sp.	●	●	–	●	●	–	●	●	–	–	–	–
Porambonites sp.	–	–	–	●	–	–	–	–	●	–	–	–
Ptychoglyptus sp.	–	–	–	–	●	●	–	–	–	–	–	–
Rafinesquina sp.	–	–	●	–	–	–	–	–	–	–	–	–
Rhactorthis sp.	●	–	–	–	–	–	–	–	–	–	●	–
Salopia sp.	–	●	–	●	–	●	●	●	–	–	●	–
Saukrodictya cf. sp. A	–	–	–	●	●	–	●	–	–	–	●	–
Schizotreta sp.	–	–	–	●	–	–	–	–	–	–	–	–
Skenidioides costatus	●	●	●	●	–	●	●	●	–	–	●	–
Sowerbyella sericea	●	●	–	●	●	●	●	●	–	–	●	●
Strophomena?	●	–	–	–	–	–	–	–	–	–	–	–
TRILOBITES												
Ampyx austinii	–	–	●	–	–	–	–	–	●	●	–	–
Arthrorhachis	–	–	–	●	–	–	–	–	–	–	–	–
Atractopyge	–	–	–	–	–	–	●	–	–	–	–	–
Autoloxolichas	●	–	–	–	–	–	–	–	–	–	–	–
Calyptaulax	●	–	–	–	–	–	●	–	–	–	–	–
Deacybele	–	–	–	–	–	–	–	●	–	–	–	–
Encrinuroides	–	–	–	–	–	–	–	–	–	–	–	●
Flexicalymene	●	–	●	–	–	–	–	–	–	–	–	–
Homalopteon sp.	–	–	–	–	–	–	–	–	–	●	–	–
Remopleurides	–	–	–	–	–	–	–	–	–	●	–	–
Tretaspis	–	–	–	–	–	●	–	–	●	–	–	–
'*Trinodus agnostiformis*'	–	–	–	–	–	–	–	–	–	●	–	–
Xylabion	–	–	–	●	–	–	–	–	–	–	–	–
OTHER ELEMENTS												
Echinosphaerites granulatus	–	–	–	●	–	●	●	●	–	–	–	–
cheirocrinid cystoid	–	–	–	●	–	●	●	–	–	●	●	–
crinoid ossicles	●	–	●	●	–	●	●	–	●	–	●	●
gastropods	●	●	●	●	–	●	●	●	●	●	–	–
ramose bryozoans	●	–	●	●	●	●	●	●	–	–	●	–
prasoporid bryozoans	●	●	–	●	–	●	●	●	–	–	●	–
tentaculitids	●	–	–	–	–	–	–	●	–	–	–	–
orthocones	●	●	●	●	–	●	●	–	–	–	–	–
bivalves	●	●	●	–	–	–	●	–	–	●	–	–
conulariids	●	–	–	●	–	●	●	–	●	●	–	–
ostracods	–	–	●	●	–	–	–	–	●	–	●	–

calculated using the formula:

$$N = A + 0{\cdot}5I + P \text{ (if } P>B\text{), or } N = A + 0{\cdot}5I + B \text{ (if } B>P\text{)}$$

where: A = no. of articulated valves, B = no. of brachial valves, P = no. of pedicle valves, I = no. of indeterminate valves.

The problems of counting different groups of animals was discussed by Lockley (1980: 171–2) for Welsh Caradoc faunal associations and by Jaannusson (1984) for Baltoscandian Ordovician sequences. In the case of groups other than brachiopods absolute numbers are given. However, for some organisms such as fragmentary bryozoans, cystoid plates and crinoid ossicles, absolute numbers are given in brackets and an equivalent number of individuals given, generally one. An arbitrary correction factor is applied to bivalves for Kildare Grange Hill House Cottage, by halving the total, on the assumption that the valves are simply disarticulated in equal proportions. This is also applied to ostracods. For trilobites the largest value of pygidia or cephala is arbitrarily taken as the number of individuals. Since brachiopods are generally the commonest animals, errors involved in counting other animals are considered as negligible.

The diverse assemblage from Kildare Grange Hill Horizon 1 is listed in Table 8. All the material consists of moulds from decalcified mudstone/siltstone. The ratio of ventral to dorsal valves is generally equal. Differences may be accounted for by the problems of identifying fragments produced by the sampling method. There is a large range of size variation between and within species, and there is no suggestion of current winnowing. The shells are disseminated through the sediment, not collected together as in a coquina. For these reasons the assemblage is treated as a palaeocommunity. Grange Hill Horizon 2 (Table 9) is very similar but has reduced frequency of fossils and the addition of common *Lingulella ovata*. The difference is partly because the rock is not decalcified. This biased the identifications in favour of larger distinctive species such as *L. ovata*, *O. divaricata* and *Platystrophia*. Another factor is that at least one thin tuff horizon is found between the two horizons, which may have subtly changed the assemblage.

Some differences between Table 8 and the faunal list of Wright (1970) should be noted. *Cyclospira* and *Bicuspina* were not collected by me, whilst taxa not recorded by Wright but collected by me include *Acanthocrania*?, *Chonetoidea, Hedstroemina, Kjerulfina, Kullervo* aff. *hibernica, Leptestiina oepiki, Lingulella ovata, Nicolella* cf. *actoniae, Petrocrania harperi* and *Philhedra*. All these were present as 1% or less of the assemblage, except for *Petrocrania* which alone constituted 13·8% of the assemblage. Wright (1970) also recorded *Eoplectodonta*, but this genus is essentially indistinguishable from *Sowerbyella* except for the presence of denticles along the hinge line. No specimens in this study showed evidence of such denticles.

The older fauna from Grange Hill House Cottage (Table 10) is somewhat anomalous in comparison with the other

Table 8 Total assemblage collected from Kildare, Grange Hill Horizon 1.

	Internal				External				Total	
	PV	BV	C	I	PV	BV	C	I	no.	%
BRACHIOPODS										
Acanthocrania?	1	–	–	–	–	1	–	–	1	0·15
Chonetoidea sp.	1	–	1	–	–	–	1	–	3	0·5
Cremnorthis parva	57	76	4	–	10	21	5	–	85	13·2
dalmanellids, indet.	23	3	3	–	7	2	–	2	27	4·2
Hedstroemina sp.	3	–	–	–	3	3	–	–	3	0·5
Kjerulfina?	1	–	–	–	–	–	–	–	1	0·15
Kullervo aff. *hibernica*	2	–	–	–	1	–	–	–	2	0·3
Leptaena sp.	6	–	1	–	3	5	–	6	10	1·5
Leptestiina oepiki	7	2	–	–	–	–	–	–	7	1·0
Lingulella ovata	–	–	–	–	–	–	–	3	3	0·5
Nicolella cf. *actoniae*	–	1	–	–	–	1	–	–	1	0·15
'*Orthambonites*' sp.	2	6	–	–	2	–	–	–	6	0·9
Orthisocrania divaricata	38	23	–	68	–	–	–	108	92	14·2
Petrocrania harperi	–	89	–	–	–	30	–	–	89	13·8
Philhedra sp.	–	–	–	–	–	1	–	–	1	0·15
Platystrophia sp.	31	34	6	–	18	13	10	13	57	8·8
Rhactorthis sp.	1	3	1	–	1	2	1	–	5	0·8
Skenidioides costatus	109	32	1	–	20	15	3	–	113	17·5
Sowerbyella sericea	28	17	1	–	12	19	1	6	33	5·1
Strophomena?	2	–	–	–	1	–	–	–	2	0·3
TRILOBITES										
Autoloxolichas cephala									3	0·5
Calyptaulax pygidium									1	0·15
Flexicalymene cephalon									1	0·15
OTHER ELEMENTS										
crinoid ossicles (7)									1	0·15
gastropods									50	7·7
ramose bryozoans									4	0·6
prasoporid bryozoans									8	1·2
tentaculitids									29	4·5
orthocones									4	0·6
bivalves									2	0·3
conulariids									1	0·15
sponge spicule									1	0·15
Total									646	99·85

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 9 Total assemblage collected from Kildare, Grange Hill Horizon 2.

	Internal				External				Total	
	PV	BV	C	I	PV	BV	C	I	no.	%
BRACHIOPODS										
dalmanellids, indet.	2	3	–	–	–	1	–	–	3	5·1
Hedstroemina sp.	7	–	–	–	1	–	–	–	7	11·9
Leptaena?	1	1	–	–	1	2	–	–	2	3·3
Lingulella ovata	–	–	1	–	–	–	–	16	9	15·3
Orthisocrania divaricata	1	3	–	1	–	–	–	2	5	8·5
Petrocrania harperi	–	2	–	–	–	4	–	–	4	6·8
Platystrophia sp.	–	1	–	–	–	2	–	1	3	5·1
Salopia?	–	1	–	–	–	–	–	–	1	1·7
Skenidioides costatus	3	–	–	–	–	–	–	–	3	5·1
Sowerbyella sericea	2	–	–	–	–	–	–	–	2	3·3
OTHER ELEMENTS										
orthocone									3	5·1
prasoporid bryozoan									3	5·1
bivalve									1	1·7
gastropods									13	22·0
Total									59	100·0

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 10 Total assemblage collected from Kildare, Grange Hill House Cottage.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
dalmanellids, indet.	–	–	–	–	2	1	–	–	2	0·4
Dolerorthis?	1	–	–	–	–	–	–	–	1	0·2
Hibernodonta?	–	3	–	–	2	1	–	3	4	0·8
Leangella?	1	–	–	–	–	–	–	–	1	0·2
Leptaena sp.	1	–	–	–	–	–	–	–	1	0·2
lingulid, indet.	–	–	–	–	–	–	–	4	4	0·8
Oanduporella cf. *reticulata*	13	10	–	–	9	6	–	–	13	2·5
Petrocrania?	–	2	–	–	–	1	–	–	2	0·4
Plaesiomys multiplicata	26	13	–	–	12	20	–	–	26	5·0
Rafinesquina sp.	8	9	–	2	10	5	–	4	12	2·3
Skenidioides sp.	3	1	–	–	–	2	–	–	3	0·6
TRILOBITES										
Flexicalymene sp. pygidia									2	0·4
Flexicalymene sp. cephala									4	0·8
Autoloxolichas cephala									3	0·6
Ampyx sp. pygidium									1	0·2
OTHER ELEMENTS										
bivalve species (106)									53	10·1
gastropod species									246	47·2
ostracods (*Tetradella*?) (132)									66	12·7
crinoid ossicles (19)									1	0·2
orthocone fragments (15)									15	2·9
tentaculitids									1	0·2
bryozoans									45	8·6
'*Mastopora*'?									15	2·9
Total									521	100·2

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Leinster faunas. It is molluscan not brachiopod dominated, with different brachiopod genera present. Five of the 11 genera are not known from the other localities and make up 10·8% of the fauna, of which only 13·4% comprises brachiopods. The fossils were excavated from muddy and tuffaceous siltstones and fine sandstones at the back of the cottage. About 2–3 metres below the fossiliferous section are fine quartz pebble conglomerates with fragments of the underlying slates.

The fossils are interpreted as having lived in a shallow water but low energy environment, perhaps close to the shore of the emergent volcanic cone of Grange Hill. Supporting evidence includes the very close proximity of lavas interpreted as being subaerial, and the abundance of an ostracod (*Tetradella*?) which elsewhere is commonly indicative of intertidal or shallow subtidal conditions.

Kilbride, within the Upper Tramore Volcanic Formation, by contrast, represents a different setting. In the small exposure there are contorted streaks and lenses of tuff in the dark siltstones, with very obscure bedding. The faunal evidence from this work and the limited field evidence supports Carlisle's (1979: 551) interpretation of slumpedvolcaniclastics, and that the lithology is a debris flow. The high diversity and low frequency of any one species suggests that faunas from different areas and substrates were 'sampled' in the downslope movement of the sediment mass. Although Carlisle (1979: 552) only listed certain genera as common and others as 'also in the fauna', the assemblage listed in Table 11 shows significant differences, reflecting a different sample. In the fauna are numerous (22) fragmentary plates of a cheirocrinid cystoid, of which 5 may be oral plates. These may belong (C.R.C. Paul, personal communication 1987) to *Hadrocystis* or *Acantholepis* (whose sole species *A. jamesi* M'Coy, 1846 was described from Raheen, Waterford Harbour). The preservation of the cheirocrinids (Plate 16, figs 12-18), which are fractured across plates and not along boundaries, also reflects the disturbed nature of this horizon. There are also 9 plates of *Echinosphaerites*, some of which are broken. Comparable examples of debris flows include that described by Lockley (1984) from Builth, central Wales and Kilbucho in Scotland (Clarkson *et al.* 1992).

Although it is reasonable to treat them as '*in situ*' faunas

Table 11 Total assemblage collected from Kilbride.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
Acanthocrania?	–	–	–	–	–	1	–	–	1	0·6
Anisopleurella?	–	1	–	–	–	1	–	–	1	0·6
Bicuspina?	–	2	–	–	–	1	–	–	2	1·1
Bimuria sp.	27	–	–	–	1	–	–	–	27	15·0
Chonetoidea cf. *abdita*	14	6	–	–	9	2	–	–	14	7·8
Cremnorthis parva	8	7	–	–	1	3	–	–	8	4·5
dalmanellids, indet.	1	–	–	–	2	2	1	–	3	1·7
Hesperorthis sp.	3	–	–	–	–	–	–	–	3	1·7
Leptestiina oepiki	6	6	–	–	1	2	–	–	6	3·3
lingulid, indet.	–	–	–	–	–	–	–	1	1	0·6
Nicolella cf. *actoniae*	10	–	–	–	8	6	–	–	10	5·6
'*Orthambonites*' sp.	8	14	–	–	1	3	–	–	14	7·7
Platystrophia sp. 2	1	3	–	–	1	1	–	–	3	1·7
Porambonites sp.	2	–	–	–	–	–	–	–	2	1·1
Salopia?	1	–	–	–	–	–	–	–	1	0·6
Saukrodictya sp.	1	–	–	–	1	–	–	–	1	0·6
Schizotreta sp.	1	–	–	–	1	–	–	–	1	0·6
Skenidioides costatus	4	4	–	–	4	7	–	–	7	3·9
Sowerbyella sericea	18	7	–	–	13	10	–	–	18	10·0
sowerbyellid, indet.	2	–	–	–	–	–	–	–	2	1·1
TRILOBITES										
cybelinid cephalon									1	0·6
lichid cephalon									1	0·6
Arthrorhachis?									1	0·6
cybelinid librigenae (5)										
illaenid? cephalon									1	0·6
Xylabion? pygidium									1	0·6
OTHER ELEMENTS										
sponge?									1	0·6
gastropods									6	3·3
ostracods									3	1·7
orthocone									1	0·6
conulariids									2	1·1
prasoporid bryozoans									16	8·9
ramose bryozoans (27)									1	0·6
coral?									1	0·6
crinoid ossicles (77)									1	0·6
cheirocrinid cystoid									17	9·4
cheirocrinid cystoid oral plates? (5)										
Echinosphaerites plates (8)									1	0·6
Total									179	100·8

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

for stratigraphical correlation, the loose block nature of assemblages from Ballykale (Table 12) and Clologe (Table 13) offers little information, although the fauna from Clologe is from two distinct lithologies, one shaly and one tuffaceous. Hiller's (1971) collections from Frankfort and Clogh also came from loose blocks. Carrigadaggan, although yielding a diverse large assemblage (Table 14), gave little information about palaeoecology, since exposure was poor and much material came from broken blocks not completely *in situ*. The coarse volcaniclastic lithology preserved details of the fossils only poorly.

The presence of *Echinosphaerites* cf. *granulatus* M'Coy (Plate 16. figs 1–7,9–10) in some abundance at Carrigadaggan, is worthy of note. It was listed as *E. aurantium* in the G.S.I. Memoir (Kinahan 1879). This species is found as almost complete individuals (6 specimens), suggesting rapid burial as in a coarse tuff fall, but there are also numerous isolated (15) or several associated plates (27) of the cystoid. Forbes (1848) monographed the British and Irish cystoid fauna, and Paul (1973, 1984) has produced a modern revision of some diploporite and rhombiferan cystoids. This material, which has been confirmed as *Echinosphaerites* (personal communication 1987) will be dealt with in the third part of Paul's monograph. Bockelie (1981) has recently reviewed the functional morphology and evolution of the genus, from many different lithologies in Russia and Scandinavia. In spite of the fact that there are several nearly complete thecae, the fact that few if any preserve evidence of a stem, cover plates of the gonopore, brachioles or oral cover plates, suggests that they were not covered by sediment immediately after death. It is difficult to be unequivocal about these taphonomic factors, or the loss of periproctal plates (which occurred in less than 5% of specimens reviewed by Bockelie, 1981: 191), since the Carrigadaggan lithology is so coarse-grained that fine detail of the plates is not always preserved. Two specimens show projections, however, one of which is believed to be an oral projection, the other possibly the basal plates to which the stolon was attached (see Plate 16, figs 7, 9, 10). Possibly the most likely explanation is that *Echinosphaerites* and the cheirocrinid cystoids, of which there are 9 fragmentary plates similar to the Kilbride material (Plate 16, figs 8,11), were buried rapidly by volcaniclastic material but were subject to current action in shallow waters rather than inundated by distal tuff falls.

Ballygarvan Bridge (Table 15) has volcanic rocks adjacent, but exposure is too poor and the sample is too limited to infer much. As previously noted, volcanic events may best account for the differences between the new collections from Raheen and the G.S.I. records (Baily *in* Kinahan 1882: 38–39). A diverse fauna of 25 species including 9 trilobites in abundance was recorded, whilst new collections (Table 16) are overwhelmingly dominated by a dalmanellid (probably *Howellites*, but remaining indeterminate because of the strong deformation) with only a few trilobites and generally low diversity. Tuff horizons (tens of cm thick) are common in the new section that was exposed and almost certainly account for apparent differences.

The Greenville assemblage (Table 17) also differs from earlier collections. Since this was collected by digging beneath a thick farmyard deposit it is most likely that different horizons were sampled, but the cause of the changes in assemblages from horizons in close succession remains unknown. In contrast, the collections from Greenville-Moyne (Table 18) probably came from the same horizon as that

Table 12 Total assemblage collected from Ballykale.

	Internal				External				Total	
	PV	BV	C	I	PV	BV	C	I	no.	%
Bimuria cf. *dyfiensis*	59	10	–	–	16	5	–	–	59	81·0
Chonetoidea	1	–	–	–	–		–	–	1	1·3
dalmanellids, indet.	2	–	1	–	1	1	1	–	3	4·2
Leptestiina sp.	2	–	–	–	–	–	–	–	2	2·7
Platystrophia	–	1	–	–	–	–	–	1	2	2·7
Ptychoglyptus	1	–	–	1	1	–	–	–	2	2·7
Saukrodictya sp.	1	–	–	–	–	–	–	–	1	1·3
Sowerbyella?	–	–	–	–	2	–	–	–	2	2·7
strophomenid, indet.	–	–	–	–	–	–	–	1	1	1·3
Total									73	99·9
OTHER ELEMENTS										
ramose bryozoans (5)										
trilobite genal spines? (3)										
trilobite thoracic segments (2)										

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 13 Total assemblage collected from Clologe Upper.

	Internal				External				Total	
	PV	BV	C	I	PV	BV	C	I	no.	%
BRACHIOPODS										
Anisopleurella?	1	–	–	–	1	–	–	–	1	1·4
dalmanellids, indet.	2	4	1	–	6	5	–	–	7	10·0
Dolerorthis?	1	1	–	–	1	–	–	–	1	1·4
Glyptorthis	–	–	–	–	–	–	–	1	1	1·4
Kjaerina?	–	–	–	1	–	–	–	1	1	1·4
Leptestiina sp.	1	2	1	–	–	–	–	–	3	4·3
Nicolella sp.	2	1	–	–	2	1	–	–	2	2·9
Oanduporella?	–	–	–	–	–	2	–	–	2	2·9
Plaesiomys?	–	–	–	–	–	–	–	1	1	1·4
Ptychoglyptus sp.	–	–	–	1	–	–	–	1	1	1·4
Salopia?	–	–	–	–	–	1	–	–	1	1·4
Skenidioides sp.	1	–	–	–	1	–	–	–	1	1·4
Sowerbyella sp.	2	–	–	–	–	–	–	–	2	2·9
strophomenid, indet.	–	–	–	1	–	–	–	2	1	1·4
TRILOBITES										
tretaspid cephala									18	25·7
tretaspid cephalon fragments (14)										
cybelinid librigenae (2)										
agnostid									1	1·4
lichid cephalon									1	1·4
cheirurid cephalon									1	1·4
OTHER ELEMENTS										
ramose bryozoans (4)									1	1·4
prasoporid bryozoans									1	1·4
orthocone									1	1·4
crinoid ossicles (4)									1	1·4
gastropods									12	17·2
conulariid									1	1·4
coral?									1	1·4
cheirocrinid cystoids									3	4·3
Echinosphaerites plates (4)										
Echinosphaerites theca									1	1·4
cystoid, indet.									2	2·9
Total									70	96·8

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 14 Total assemblage collected from Carrigadaggan.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
Bicuspina?	–	–	1	–	–	–	–	–	1	0·3
Bimuria?	–	–	–	–	–	1	–	–	1	0·3
Cremnorthis parva	5	3	1	–	1	1	–	–	6	1·6
dalmanellids, indet.	47	14	4	–	25	17	–	–	51	13·2
Dolerorthis?	1	2	–	–	–	–	–	–	2	0·5
Glyptorthis?	–	–	–	–	–	–	–	1	1	0·3
Kullervo aff. *hibernica*	3	2	–	–	3	1	–	4	5	1·3
Leptellina cf. *llandeiloensis*	4	3	–	–	–	–	–	–	4	1·0
Leptestiina oepiki ampla	29	10	–	–	4	4	–	–	29	7·5
lingulid, indet.	–	–	–	–	–	–	–	4	2	0·5
Nicolella cf. *actoniae*	–	–	–	–	–	7	–	–	7	1·8
'*Orthambonites*' sp.	4	11	–	–	2	4	–	–	11	2·8
Orthisocrania divaricata	1	1	–	–	–	–	–	5	4	1·0
Oxoplecia?	–	1	–	–	–	1	–	1	2	0·5
Platystrophia sp.	5	7	1	–	3	1	1	–	9	2·3
plectambonitacean, indet.	–	–	–	–	–	2	–	–	2	0·5
Salopia?	1	1	–	–	–	–	–	–	1	0·3
Saukrodictya cf. sp. A	1	–	–	–	3	1	–	4	5	1·3
Skenidioides costatus	3	–	–	–	–	2	–	–	3	0·8
Sowerbyella sericea	–	2	–	–	1	4	–	–	4	1·0
triplesiid indet. 1	–	–	1	–	–	–	–	–	1	0·3
triplesiid indet. 2	2	–	–	–	–	–	–	–	2	0·5
TRILOBITES										
trinucleid pygidia (1)										
trinucleid cephala									5	1·3
Atractopyge pygidia									18	4·6
Atractopyge cephala (9)										
cybelinid librigenae (15)										
lichid cephala									2	0·5
illaenid? cephala									1	0·3
Calyptaulax? cephalon									1	0·3
OTHER ELEMENTS										
prasoporid bryozoans									75	19·4
ramose bryozoans									42	10·8
gastropod species									29	7·5
conulariids									27	7·0
bivalves									2	0·5
crinoid ossicles (46)									1	0·3
orthocones									11	2·8
coral?									1	0·3
Echinosphaerites single plates (15)										
Echinosphaerites attached plates (27)									5	1·3
Echinosphaerites thecae									5	1·3
cheirocrinid cystoid									9	2·3
Total									387	100·1

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 15 Total assemblage collected from Ballygarvan Bridge.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
dalmanellid, indet.	4	1	–	–	5	1	–	–	5	6·75
Lingulella ovata	–	–	–	–	–	–	–	3	2	2·7
Nicolella cf. *actoniae*	1	–	–	–	1	–	–	–	1	1·35
Platystrophia sp.	1	1	–	–	1	1	–	–	1	1·35
Salopia?	1	1	–	–	1	1	–	–	1	1·35
Skenidioides sp.	1	–	–	–	1	–	–	–	1	1·35
Sowerbyella sp.	–	1	–	–	–	1	–	–	1	1·35
TRILOBITES										
calymenid pygidium									1	1·35
Deacybele cephalon									1	1·35
OTHER ELEMENTS										
prasoporid bryozoans									20	27·0
ramose bryozoans (2)									1	1·35
gastropods									37	50·0
tentaculitid									1	1·35
Echinosphaerites theca									1	1·35
Total									74	99·95

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 16 Total assemblage collected from Raheen.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
Chonetoidea sp.	3	1	–	–	2	–	–	1	4	2·9
dalmanellid (*Howellites*?)	76	44	–	–	61	54	5	–	81	59·6
Porambonites?	1	–	–	–	–	–	–	–	1	0·7
strophomenid, indet.	2	–	1	–	2	–	–	–	3	2·2
TRILOBITES										
Ampyx pygidia									2	1·5
Tretaspis cephalon									1	0·7
tretaspid cephalon									1	0·7
tretaspid cephalic fragments (2)										
tretaspid pygidium (1)										
OTHER ELEMENTS										
crinoids (5)									1	0·7
gastropods									36	26·5
ostracods									2	1·5
conulariids									2	1·5
orthocones									2	1·5
Total									136	100·0

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

recorded by Brenchley *et al.* (1977) and slightly increase the genera known from here.

Ballinatray (Table 19) preserves a rare occurrence of shelly fossils in a normally graptolitic facies. Coastal sections of the Ballinatray Formation north of Courtown have hitherto yielded only graptolites (Crimes & Crossley 1968, Brenchley & Treagus 1970). Shells are found in thin, densely packed bands in calcareous slates. Restricted exposure in the bed and banks of the Owenavorragh River and strong deformation make assessment difficult, but the lack of size variation, restricted diversity and dense packing suggest that the fauna was a coquina. Whether long distance transport or local winnowing was involved is not clear, but all specimens are small including the rare genera, elsewhere of a normally larger size.

Table 17 Total assemblage collected from Greenville.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
Chonetoidea abdita	24	25	–	1	31	47	–	27	61	41·5
dalmanellids, indet.	–	–	–	–	4	1	–	–	4	2·7
Oanduporella?	1	–	–	–	3	1	–	–	3	2·0
TRILOBITES										
Remopleurides sp. cephala									5	3·4
Homalopteon sp. pygidium									1	0·7
Ampyx austinii cephala (8)										
Ampyx austinii glabellar spines (7)										
Ampyx austinii pygidia									16	10·9
'*Trinodus*' *agnostiformis* pygidia?									8	5·4
Tretaspis cephalon									1	0·7
trinucleid cephala									4	2·7
trinucleid pygidia (2)										
trinucleid thoraces (2)										
trinucleid genal spines (2)										
OTHER ELEMENTS										
cheirocrinid cystoid									1	0·7
gastropods									38	25·9
bivalve									1	0·7
conulariids									4	2·7
Total									147	100·0

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Comparisons and contrasts with coeval associations

A prerequisite to recognition of faunal provinciality in brachiopod assemblages is the determination of whether apparently different faunas are simply facies controlled. This was undertaken as an integral part of this project and is briefly summarised here. Due to the problems noted before, only some localities yielded assemblages which could be treated as palaeocommunities. These were Grange Hill Horizon 1, Grange Hill House Cottage, Carrigadaggan, Raheen, Greenville and Greenville-Moyne.

In fact, the assemblages are clearly dissimilar to platform sequence faunas from Laurentia, and to the marginal Scoto-Appalachian faunas from Ireland and Britain. Few assemblages of similar age from the Lake District are known and there are no modern quantitative studies for direct comparison. Essentially, only comparisons with Anglo-Welsh associations were applicable. Principal Component Analysis (PCA) using Palstat (Harper & Ryan 1987) is an effective way of discriminating and illustrating the elements which contribute most to the variation between samples. One example is given to illustrate the comparitive analysis undertaken. Figure 15 shows a plot of vector 1 against vector 3 for the Grange Hill Horizon 1 association and 11 samples of the *Nicolella* Association from the Gelli-grîn Formation from Lockley (1980). Plots of vector 1 against 2 discriminated abundance trends of dalmanellids. The plot in Fig. 15 clearly differentiated the Grange Hill elements as contributing substantially to the variation on vector 3. Whilst not a precise test, it shows important differences which do not permit the association to be considered as an equivalent to the *Nicolella* Association,

Table 18 Total assemblage collected from Greenville-Moyne.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
Anisopleurella sp.	8	2	–	–	2	5	–	–	8	6·0
Cremnorthis parva	8	2	–	–	–	–	–	–	8	6·0
dalmanellids, indet.	39	16	6	–	19	17	–	–	45	33·6
Dolerorthis?	1	1	–	–	–	–	–	–	1	0·75
Kullervo aff. *hibernica*	3	–	–	–	3	2	–	2	4	3·0
Leptestiina oepiki	3	2	–	–	–	–	–	–	3	2·2
lingulid, indet.	–	–	–	–	–	–	–		11	0·75
Nicolella cf. *actoniae*	3	4	1	–	4	7	–	–	8	6·0
'*Orthambonites*'?	5	4	–	–	1	1	–	–	5	3·7
Orthisocrania?	–	–	–	–	–	–	–	1	1	0·75
plectambonitacean, indet.	–	–	–	–	–	–	–	2	1	0·75
Rhactorthis?	1	–	–	–	1	–	–	–	1	0·75
Salopia sp.	–	4	–	–	–	1	–	–	4	3·0
Saukrodictya cf. sp. A	–	–	–	–	–	–	–	2	1	0·75
Skenidioides costatus	1	–	–	–	1	–	–	–	1	0·75
Sowerbyella?	3	–	–	–	2	1	–	–	3	2·2
strophomenid, indet.	–	1	–	–	–	1	–	–	1	0·75
TRILOBITES										
cybelinid? librigenae (8)										
indet. pygidia (1)										
indet. cephala (2)									2	1·5
OTHER ELEMENTS										
crinoid ossicles (14)									1	0·75
prasoporid bryozoans									22	16·4
ramose bryozoans									7	5·25
cheirocrinid cystoids									3	2·2
ostracods									3	2·2
Total									134	100·0

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

Table 19 Total assemblage collected from Ballinatray.

	Internal PV	BV	C	I	External PV	BV	C	I	Total no.	%
BRACHIOPODS										
Chonetoidea sp.	1	–	–	–	–	–	–	–	1	1·8
dalmanellids, indet.	38	26	–	–	8	10	–	14	45	78·9
Dolerorthis?	1	2	–	–	–	–	–	–	2	3·5
Leptestiina sp.	1	1	–	–	–	–	–	–	1	1·8
plectambonitacean, indet.	1	2	–	–	–	–	–	3	4	7·0
Sowerbyella?	1	–	–	–	–	–	–	–	1	1·8
TRILOBITES										
Encrinuroides? pygidia									2	3·5
OTHERS										
crinoid ossicle									1	1·8
Total									57	100·1

PV = pedicle valves, BV = brachial valves, C = conjoined valves, I = indeterminate valves, NO. = equivalent number of total animals. (N.B. Numbers in brackets are total fragments of colonial or fragmented individuals – see discussion). See discussion on p.127.

sensu Lockley (1980). Principal of these are the abundance of the calcareous inarticulates *O. divaricata* and *P. harperi*, and the much greater frequency of *Skenidioides and Cremnorthis* at Kildare than in the Welsh Longvillian.

Pickerill & Brenchley (1979) studied the faunal communities of the south Berwyn Hills of N. Wales, and defined communities very similar to those of Lockley (1980). Direct comparison using PCA was not possible due to their data presentation. For their *Nicolella* Community simple inspection shows that the Grange Hill association does not equate (Table 20). This aspect of the study highlighted the benefits of recording raw palaeontological data, as suggested by Lockley (1980: 167). As Jaannusson (1984: 127) noted, there are many published studies which cannot be compared because of differences in tabulation of quantitative data. The example of the Grange Hill Horizon 1 assemblage compared with the Welsh *Nicolella* Association is a typical one. The analysis of the suitable assemblages from Leinster in relation to Welsh and English Caradoc (Hurst 1979a, 1979b, Pickerill & Brenchley 1979, Lockley 1980) and especially Lockley's (1983) rigorous definition of eight palaeocommunities is discussed in more detail in Parkes (1990). The moderate to severe differences evident precluded placement of the Leinster assemblages into those palaeocommunities.

The localities from Leinster are in volcano-sedimentary sequences associated with island arc volcanism. The rapid facies changes over short distances, with little or no shelf development and invasion of volcanic detritus into clastic substrates are sufficient to explain this lack of comparable

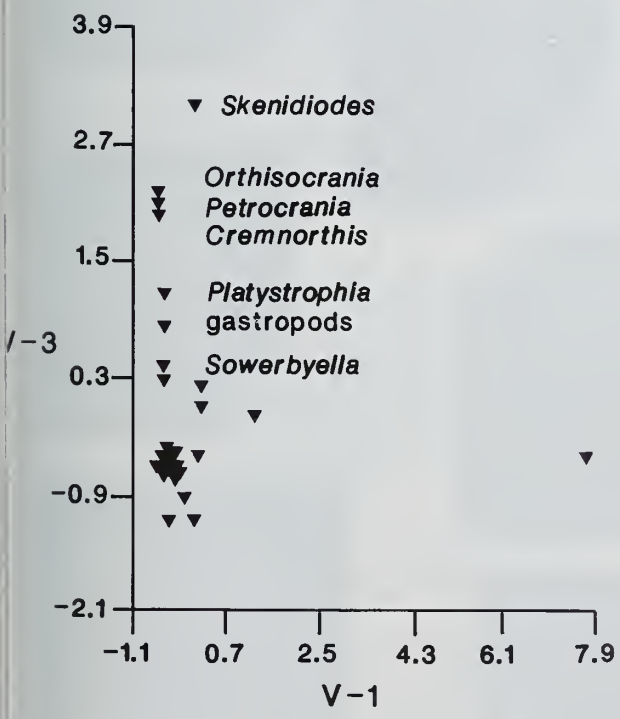

Fig. 15 Principal Component Analysis of Kildare Grange Hill Horizon 1 association with Gelli-grîn Formation *Nicolella* Association samples: plot of vector 1 against vector 3. *Data sources*: Association 1: Table 8 (p. 128), Grange Hill Horizon 1. Associations 2–11, Gelli-Grîn Formation. From Lockley, 1980: fig. 12 (GG1h, GG1g1, GG1b); fig. 13 (GG2d, GG2b); fig. 14 (TB 16, TB 12); fig. 15 (R34, R30, R28).

Table 20 Nucleus of *Nicolella* Community as defined by Pickerill & Brenchley (1979), compared to nucleus of Grange Hill Horizon 1 association.

Nicolella Community		Kildare, Grange Hill, Horizon 1	
Nicolella	34%	*Skenidioides*	18%
Dolerorthis	21%	*Orthisocrania*	14%
Platystrophia	16%	*Petrocrania*	14%
Skenidioides	9%	*Cremnorthis*	13%
Leptestiina	6%	*Platystrophia*	9%
Eoplectodonta	4%	gastropods	8%
Howellites	3%	*Sowerbyella*	5%
Sowerbyella	3%	tentaculitids	4%
Cremnorthis	<1%	dalmanellids, indet.	4%

community development. Lockley (1983) concluded that the Welsh Basin, with low facies gradients for much of the Ordovician rather than basin margin localities, provided more stable sites for the evolution of diverse, well established palaeocommunities.

Biogeography

The component brachiopod species of the Duncannon Group assemblages are best understood when viewed in terms of species migrations and palaeogeographical changes. Harper and Parkes (1989), Harper *et al.* (1991) and Murphy *et al.* (1991) have dealt partially with the faunas described here. A more complete treatment of their biogeographical context is contained in Parkes (1992) and is not reiterated here.

In summary, these faunas are ascribed to a distinct Anglo Welsh Province centred on Eastern Avalonia in the Caradoc. Despite the lack of comparable palaeocommunity development, there are numerous congeneric and conspecific forms, many with an earlier origin in migrations from the Baltic Province. Specific appearances of Scoto-Appalachian e.g. *Leptellina* and *Bimuria*, and Mediterranean Province genera e.g., *Saukrodictya*, can also be tracked as provinciality was diminished by northward movement of Avalonia towards Laurentia and low latitudes (Fig. 16, p.146). They are also significant in constraining volcanic and tectonic events. Lavas at Grange Hill, Kildare are tightly constrained to the Soudleyan – Longvillian interval. Although the stratigraphical position of the other faunas is not so clear, the data from this study support recent ideas that subduction-related volcanism ceased in the mid Caradoc (Pickering *et al.* 1988, Leat & Thorpe 1989). The biogeographical analysis of Ordovician faunas is an important facet of understanding the development of the Caledonides by Iapetus closure. Discovery of new assemblages may provide new evidence, but revision of faunas from old localities such as this work and Parkes (1992) is equally important. Furthermore, new methods of analysis such as seriation (Parkes *et al.* 1990) may also reveal clearer distribution patterns.

SYSTEMATIC PALAEONTOLOGY

For the better preserved, larger samples, the 'material' section of each description includes only the measured sample on which the statistical data are based and excludes


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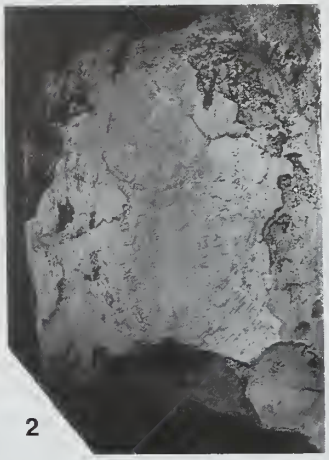
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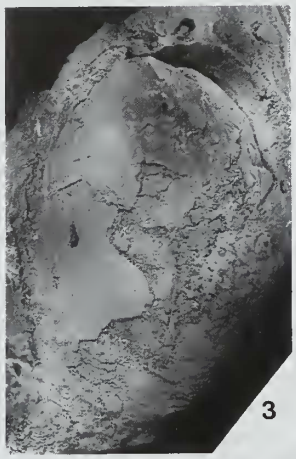
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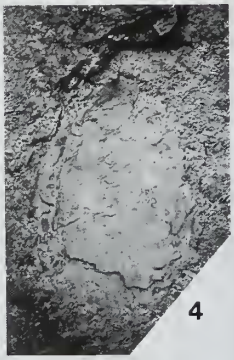
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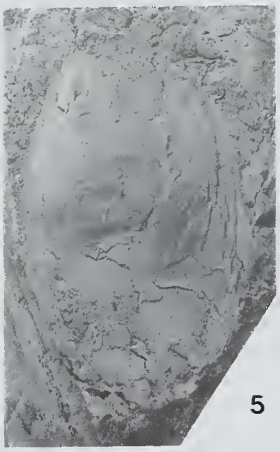
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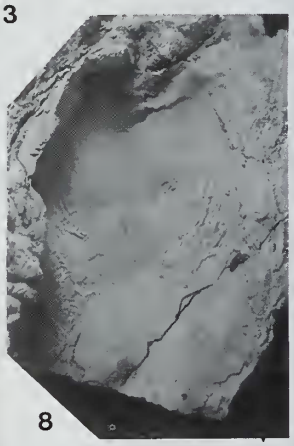
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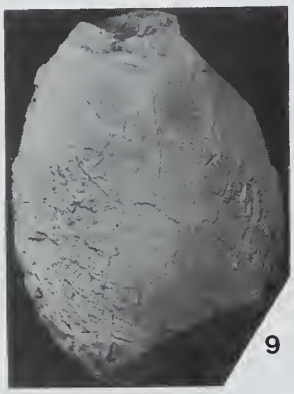
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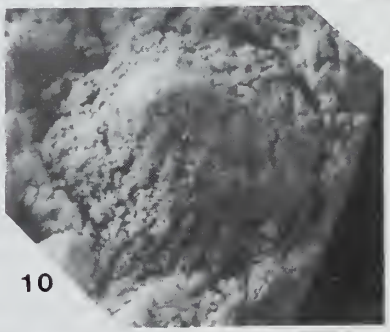
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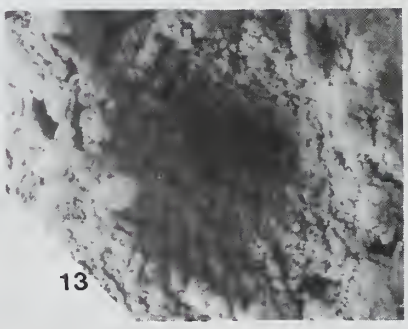
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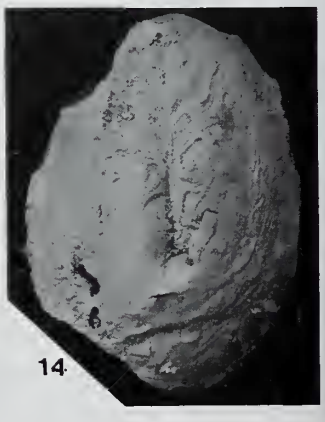
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the fragmentary material included in the Tables 8–19. For some genera the available material did not merit a full taxonomic statistical description. In these cases the best representative forms are figured, and for this material dimensions are given in the systematic section, if the magnification is not an adequate indication. Full data sets are given for any statistically described species in a supplementary document lodged at The Natural History Museum (see p.118) or available from the author. In addition to the material described or noted in this section, there were some poorly preserved or fragmentary specimens, often of questionable identity, which were not worthy of discussion but are listed in the locality Tables (8–19). Inevitably, for each locality there were a few unidentified specimens.

In this study, the dalmanelloid brachiopods were a common, albeit minor, element of most faunas. Although species lineages are stratigraphically useful (e.g. Hurst 1979*a*), the recognition of different genera and species is dependent on the measurement of small morphological variations in the cardinalia, musculature and shell outline, as well as aspects of the costellate ornamentation. In the localities sampled by me, dalmanelloids were present in most cases, although as minor constituents of the assemblage, except at Raheen where one species was dominant. Their poor preservation, small sample numbers and frequent tectonic deformation made it difficult to make confident identifications; they are therefore listed as 'indeterminate dalmanellids' in the relevant tables. The identification of the less common elements in the faunas, such as bivalves, ostracods, gastropods and crinoids was outside the scope of the project, and in any case most material was poorly preserved and generic identification would have been somewhat equivocal. However, a few elements such as the cystoid *Echinosphaerites* are figured.

All material, other than that figured, is housed in the James Mitchell Museum (JMM) in the Department of Geology, University College Galway. The systematic classification of the Brachiopoda is based largely on Cocks (1978), and Cocks & Rong (1989) for the Plectambonitoidea.

Phylum **BRACHIOPODA**
Class **INARTICULATA** Huxley, 1869
Order **LINGULIDA** Waagen, 1885
Superfamily **OBOLOIDEA** King, 1846
Family **OBOLIDAE** King, 1846
Subfamily **LINGULELLINAE** Schuchert, 1893
Genus ***LINGULELLA*** Salter, 1866

Lingulella ovata M'Coy, 1846 Pl. 1, figs 1–9, 11, 14

1846 *Lingula ovata* M'Coy: 24; pl. 3, fig. 1.
1866 *Lingula ovata* M'Coy; Davidson: 38; pl. 2, figs 19–23.
1866 *Lingula obtusa* Hall?; Davidson: 52; pl. 3, figs 31, 32.
cf. 1963 *Lingulella* cf. *ovata* (M'Coy); Williams: 344; pl. 1, figs 1–3.
1978 *Lingulella ovata* M'Coy; Cocks: 15, 171, 172.
cf. 1980 *Lingulella* cf. *ovata* (M'Coy); Lockley: 203, fig. 25.
cf. 1980 *Lingulella* sp. A; Hiller: 123, figs 11–15.

MATERIAL AND LOCALITY. Kildare, Grange Hill, Horizon 2: 8 single valves, 1 conjoined pair of valves.

DESCRIPTION. *Exterior*. Very large equally biconvex, elongately oval valves with acute beak. Maximum width at 66% of length although sides nearly parallel. Shell variably buff, brown and black coloured, ornamented with fine concentric growth lines on lateral and anterior margins, nearly smooth centrally. Occasional faint radial striations medially towards anterior margin. Depth of valves 10% of length. Width is 60% of length.

Ventral interior. Not positively known, but one specimen shows smooth surface with faint median striations towards anterior margin.

Dorsal interior. Two specimens show dorsal median septum, extending 50% and 70% of the length, expanding in width and height anteriorly. The growth lines are deflected anteriorly by the median septum.

DISCUSSION. M'Coy (1846) described the species from three localities; Ballygarvan Bridge, Kildare and Newtown Head, Co. Waterford. Cocks (1978) selected the lectotype (NMING:F4578) from the Chair of Kildare. He stated it was from the Kildare Limestone Formation (Rawtheyan), but M'Coy recorded it as 'common in the shale of Chair of Kildare' which is actually the lithology of the Grange Hill locality. The opportunity is taken here to figure some good topotype material. The Griffith Collection specimen in the N.M.I. (F5482), a paralectotype from Ballygarvan Bridge, accords with the type material in its proportions, although it is only the anterior half of a valve. A significant feature revealed by a larger sample is the very large size which this species can attain. M'Coy (1846) records the length as one inch three lines (*c.* 32 mm) but the largest specimen collected is 43 mm long, although much smaller specimens are also present. It appears that this large size is probably normal for the species rather than representing a population which realised optimal conditions for growth, as suggested by Pickerill (1973) in a study of *Lingulasma tenuigranulata* from North Wales. Harper (1984: 19), in noting the similarity of *L. carrickensis carrickensis* to *L. ovata*, raised the problems of Ordovician *Lingulella* taxonomy. The sample described here may help facilitate a future multivariate morphometric analysis of described species. Moreover *L. ovata* may prove ultimately to be a synonym of *L. brevis* (Portlock, 1843), as noted by Mitchell (1977). The relative proportions are similar but the Pomeroy sample is considerably smaller in mean size.

PLATE 1

Figs 1–9, 11, 14 *Lingulella ovata* M'Coy. Kildare, Grange Hill Horizon 2. **1**, BC 12634a, interior, × 2. **2**, BC 12369, exterior, × 2. **3**, BC 12635a, exterior, × 13. **4**, BC 12636, exterior, × 3. **5**, BC 12637, exterior, × 2. **6**, BC 12638, interior, × 137. **7**, BC 12634b, interior, × 2. **8**, BC 12640b, interior, × 2. **9**, **11**, **14**, BC 12640a, internal mould, counterpart of Fig. 8; 9, ventral view, × 2; 11, dorsal view, × 14; enlarged dorsal view showing median septum, × 2.

Fig. 12 *Schizotreta* cf. *corrugata* Cooper. Kilbride. BC 12641b, pedicle valve exterior, × 4.

Figs 10, 13 *Acanthocrania*? sp. Kildare, Grange Hill Horizon 1. Brachial valve. 10, BC 12642a, internal mould, × 10. 13, BC 12642b, external mould, × 10.

Superfamily **DISCINOIDEA** Gray, 1840
Family **DISCINIDAE** Gray, 1840
Subfamily **ORBICULOIDEINAE** Schuchert & Le Vene, 1929
Genus ***SCHIZOTRETA*** Kutorga, 1848

Schizotreta cf. ***corrugata*** Cooper, 1956 Pl. 1, fig. 12

1956 *Schizotreta corrugata* Cooper: 277; pl. 21, figs 7–20; pl. 28, figs 24–28.
cf. 1977 *Schizotreta* cf. *corrugata* Cooper; Mitchell: 25; pl. 1, figs 26–30.
cf. 1984 *Schizotreta* cf. *corrugata* Cooper; Harper: 39; pl. 4, figs 3–5.

MATERIAL AND LOCALITY. Kilbride: a single internal and external mould of a pedicle valve.

DESCRIPTION. Almost circular, transversely elliptical shell, with length 95% of width. Ornament of raised concentric ridges crowded together on either side of the umbo, numbering 6 per mm between 3 and 4 mm anterior of the approximate position of the umbo. Details of umbo not seen owing to poor preservation.

Ventral interior. Smooth, preservation too poor for detail except faint limbus. (Dorsal valve unknown.)

MEASUREMENTS. BC 12641: (X1) length = 76 mm, (X2) width = 8 mm (Pl. 1, fig. 12).

DISCUSSION. The size, shape and ornament suggest this is very similar to *S. corrugata*, especially in the asymmetry of the apex and the lateral profile of slightly concave posterior slope and flat anterior slope. The species is recorded from Pomeroy and Girvan although in similarly sparse numbers.

Suborder **CRANIIDINA** Waagen, 1885
Superfamily **CRANIOIDEA** Menke, 1828
Family **CRANIIDAE** Menke, 1828
Genus ***ACANTHOCRANIA*** Williams, 1943

Acanthocrania? sp. Pl. 1, figs 10, 13

MATERIAL AND LOCALITY. Kildare, Grange Hill, Horizon 1: A single internal and external mould of a brachial valve.

MEASUREMENTS. BC 12642b: X1 = 4·6 mm, X2 = 5·0 mm, X4 = 2·3 mm (Pl. 1, fig. 13).

DISCUSSION. The preservation of this single valve, equivocally assigned to *Acanthocrania*, is poor. It is steeply conical with umbo? closer to the posterior margin. The depth is 50% of the length, a figure close to the Portrane species *A. cracentis* Wright, 1963, but greater than the *Acanthocrania* sp. of Mitchell (1977) from the Killey Bridge Formation at Pomeroy. The internal features are not seen, but the exterior has an impression of an oblique ribbing pattern.

Genus ***ORTHISOCRANIA*** Rowell, 1963

Orthisocrania divaricata (M'Coy, 1851) Pl. 2, figs 1–8

1846 *Crania antiquissima* ? Eichwald; M'Coy: 25.
1851 *Pseudocrania divaricata* M'Coy: 187; pl. 1, H, figs 1, 2.
1852 *Pseudocrania divaricata* M'Coy, *in* Sedgwick & M'Coy: pl. 1, H, figs 1, 2.
1853 *Crania divaricata* Davidson: 122; pl. 4, figs 246, 247.
1858 *Crania catenulata* (Salter MS); Baily, *in* Jukes *et al.*: 9, fig. 3.
1859 *Crania divaricata* Salter: 212, fig. 2.
1866 *Crania* (*Pseudocrania*) *divaricata* M'Coy; Davidson: 78; pl. 8, figs 7–12.
1875 *Crania divaricata* M'Coy; Baily: 32; pl. 11, fig. 5.
1963 *Orthisocrania divaricata* M'Coy; Rowell: 39.
cf. 1963 *Pseudocrania* cf. *divaricata* M'Coy; Williams: 345; pl. 1, figs 4, 5.
1965 *Orthisocrania divaricata* M'Coy; Rowell, *in* Williams *et al.*: H290, fig. 181, 6a–6c.
1970 *Orthisocrania divaricata* M'Coy; Wright: 97.
? 1976 *Orthisocrania* sp.; Neuman: 19; pl. 1, figs 1, 2.
1978 *Orthisocrania divaricata* M'Coy; Cocks: 30.
? 1980 *Orthisocrania sp.; Lockley: 205, figs 31a, b.*

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 1: 41 external moulds, 10 internal moulds of brachial valves, 14 internal moulds of pedicle valves, 2 indet. internal moulds. Kildare, Grange Hill, Horizon 2: 1 internal mould of a pedicle valve, 3 internal moulds of brachial valves, 2 external moulds. Carrigadaggan: 1 internal mould of a pedicle valve, 1 internal mould of a brachial valve.

DESCRIPTION. *Exterior*. Unattached, shallowly biconvex equidimensional valves. Outline is subcircular to subquadrate with mean length equal to width, although mean position of maximum width (X3) is at 62% of the length from the posterior margin. Shell is calcareous and punctate. Ornament of fine costellae, mean value of 15 per 5 mm at 10 mm to the anterior of the beak. Growth is mixoperipheral from marginal beak, occasionally holoperipheral in larger specimens. Faint concentric growth lines on outer margins of larger specimens.

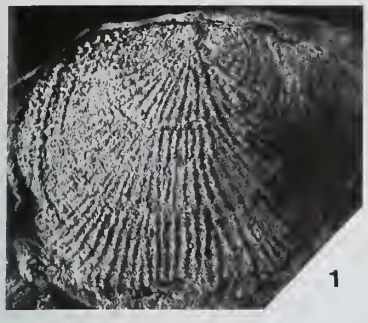
Ventral interior. The broad flat limbus is widest at the anterior and posterior shoulders, non-pustulose and is approximately 30% of the width. Large oval or elliptical anterior adductor scars are slightly elevated from shell floor.

PLATE 2

Figs 1–8 *Orthisocrania divaricata* (M'Coy). Kildare, Grange Hill Horizon 1. **1**, BC 12643, latex cast of external mould, × 4. **2**, BC 12644, external mould, × 4. **3**, BC 12645, internal mould of brachial valve, × 2. **4**, BC 12646, internal mould of pedicle valve, × 2. **5**, BC 12647, internal mould of brachial valve, × 2. **6**, BC 12648, latex cast of internal mould of brachial valve, × 2. **7**, BC 12649, internal mould of pedicle valve, × 2. **8**, BC 12650, internal mould of pedicle valve, × 2.

Figs 9–15 *Petrocrania harperi* sp. nov. Kildare, Grange Hill Horizon 1. **9**, **12**, BC 12651, external mould of brachial valve, and latex cast, both × 4. **10**, BC 12652, internal mould of brachial valve, × 4. **11**, **Holotype** BC 12653, internal mould of brachial valve, × 4. **13**, BC 12654, internal mould of brachial valve, × 4. **14**, BC 12655, internal mould of brachial valve, × 4. **15**, BC 12656, latex cast of external mould of brachial valve, × 4.

Figs 16–17 *Philhedra* sp. Kildare, Grange Hill Horizon 1. BC 12657, latex cast of external mould of brachial valve, lateral and dorsal views, × 2.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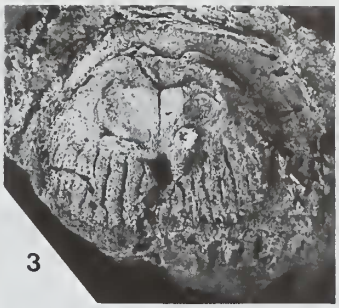
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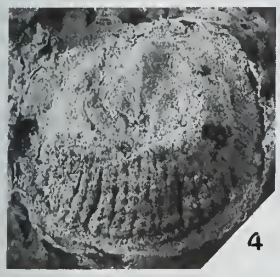
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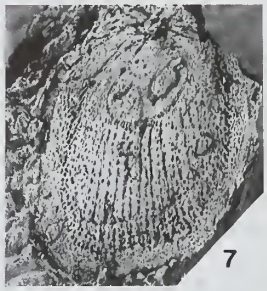
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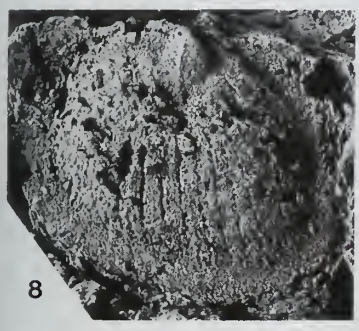
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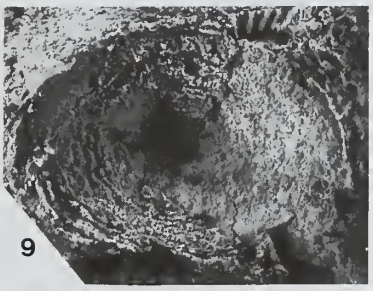
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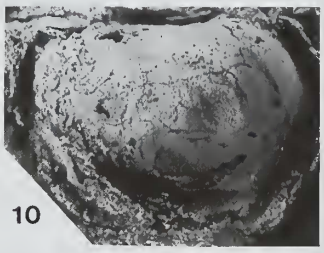
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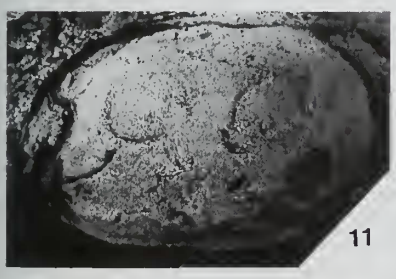
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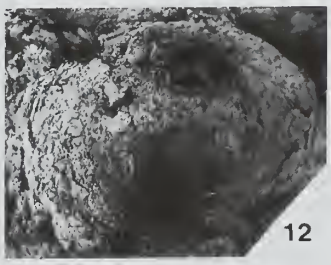
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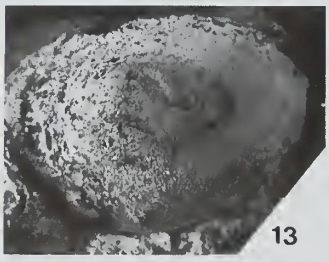
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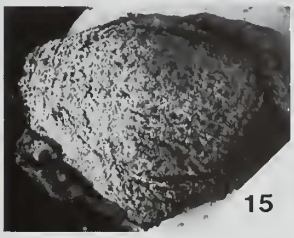
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The posterior scars are smaller and less impressed. The anterior half of the shell is marked by numerous narrow ridges with broader flat interspaces, giving a very distinct pallial sinus pattern. The anterior scars are divergent from the posterior side of the mid length, towards the postero-lateral margins.

Dorsal interior. Similar in most respects to the ventral interior. Additional muscle scars on a small raised platform sagittally anterior of the anterior adductor scars.

MEASUREMENTS
External moulds:

Variates	X1	X2	X3
Means	16·4	16·8	9·79
Sample size	40	41	40
Variance-covariance	14·56	8·33	8·34
Matrix		15·0	4·38
			6.20

Brachial valve internal moulds:

Variates	X1	X2	X3	X8	X9
Means	16·6	17·2	10·0	2·66	8·23
Sample size	10	10	10	10	9
Variance-covariance	6·72	3·27	5·82	0·93	1·37
Matrix		6·98	4·19	0·97	–0·96
			5·76	0·91	1·06
				0·28	0·03
					1·97

Pedicle valve internal moulds:

Variates	X1	X2	X3	X8	X9
Means	17·9	17·6	11·1	2·99	8·95
Sample size	13	14	12	14	11
Variance-covariance	8·01	0·60	3·78	0·28	1·79
Matrix		9·40	0·39	0·71	0·08
			2·71	0·13	1·69
				0·19	–0.11
					1.62

DISCUSSION. Davidson (1866) provided the most complete description of this species. Although Rowell (1963) diagnosed the genus his description is sparse and no specimens are figured. The sample described herein is the first modern description of a reasonably large sample of the species with detailed morphological measurements. Rowell (1963) gave a detailed history of the complex taxonomic types, and clearly differentiated between *Orthisocrania* and the similar *Pseudocrania* on the basis of external ornament and pseudointerareas present in the former genus. Other modern systematic records, e.g. Williams (1963), Lockley (1980) and Neuman (1976), have described only very limited or dubious material, although the preservation of Williams' (1963: 345, fig. 4; pl. 1, fig. 5) brachial valve internal mould enabled him to interpret the interior impressions better than the material described herein. This material is too inadequately preserved to be unequivocal about the presence of pseudointerareas.

In the absence of modern taxonomic references to the Baltic species of the genus, the principal characters separating them remain unknown. Published figures (Heune 1899) and photographs (from D.A.T. Harper) of Baltic specimens show little difference, although the mean number of costellae in *O. divaricata* is apparently less than in *O. planissima*. Modern revision may show many of these species to be synonymous.

Genus *PETROCRANIA* Raymond, 1911

Petrocrania harperi sp. nov. Pl. 2, figs 9–15

NAME. For Dr D.A.T. Harper.

DIAGNOSIS. Variably convex to conical brachial valve of oval to subcircular outline, wider than long. Posterior slope to apex concave, anterior slope convex. Apex situated at one third length from posterior margin; ornament of concentric growth lines, coarser peripherally. Dorsal interior with characteristic pair of circular anterior muscle scars between apex and mid length. Posterior scars not seen or poorly impressed. Narrow limbus sometimes developed. Ventral valve unknown.

HOLOTYPE. BC 12653 (Pl. 2, fig. 11). Paratypes BC 12651–2, BC 12654–6. Kildare Grange Hill Horizon 1.

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 1: 32 internal moulds of brachial valves, 4 external moulds of brachial valves. Kildare, Grange Hill, Horizon 2: 2 internal and 4 external moulds of brachial valves.

DESCRIPTION. *Exterior*. Shallowly convex to conical brachial valves with apex situated posteriorly. Shell outline generally oval but variable from subcircular to occasionally subtriangular. Length less than width, 90% mean value, and mean depth 45% of length. Apex situated at mean value of 36% of length. Maximum width at 60% of length. Posterior slope to apex concave, occasionally flat or convex. In a few specimens the apex overhangs posterior margin. Anterior slope from apex convex, occasionally flat. Anterior profile conical to evenly convex. Ornament of concentric growth lines, variable from fine to coarse, generally coarser peripherally. Pedicle valve unknown.

Dorsal interior. Characteristic pair of circular anterior muscle scars as faint raised areas, situated at position between apex and 51% of length of shell. Smooth interior with faint posterior scars occasionally seen. Some moulds have a faint narrow limbus. (*Ventral interior* unknown).

MEASUREMENTS
Brachial valve internal moulds:

Variates	X1	X2	X3	X4	X9	X12
Mean	8·57	9·88	5·08	3·88	5·04	3·02
Sample size	32	32	29	32	16	30
Variance-covariance	5·92	6·26	3·88	2·35	1·01	1·93
Matrix		10·46	3·54	3·21	1·17	1·89
			3·09	1·58	0·37	1·32
				2·42	0·0	1·02
					1·10	0·48
						1.60

Discussion. In spite of the variability in a moderately large sample the species is well defined, although it is only doubtfully assigned to *Petrocrania*. This species does not possess the radial ornament characteristic of *Philhedra* (Wright 1963), neither does it have the spinose ornament of *Acanthocrania*, although craniid taxonomy is in need of revision. Since the status of *Philhedrella* is in some doubt (Wright 1963; Harper, 1989 personal communication) this material is assigned to *Petrocrania* on the basis of the external ornament. This is in spite of its apparently larger anterior adductor scars, supposedly a characteristic of *Philhedrella* (Wright 1963), and although the reverse is considered an important feature of *Petrocrania*. However, the material described here may simply have poorly impressed posterior scars, or even be relatively juvenile specimens of a large species for the genus. The internal morphology does not show much similarity to any described species. It resembles *Petrocrania dubia* Williams (1974), from the Soudleyan Whittery Shales in the Shelve district of Shropshire, in having (probably) larger anterior adductor scars, but differs in the apex being situated posteriorly rather than medially. Pedicle valves were not found in this sample.

Genus ***PHILHEDRA*** Koken, 1889

Philhedra sp. Pl. 2, figs 16, 17

Material and locality. Kildare, Grange Hill, Horizon 1: 1 single external mould of a brachial valve.

Description. *Exterior.* Irregularly conical subcircular convex valve, slightly asymmetrical apex. Ornament of irregular radial ribs, from apex to margins of valve. (*Interior* unknown.)

Measurements. BC 12657: (X4) depth = 9 mm, (X2) max. diameter = 124 mm (Pl. 2, figs 16, 17).

Discussion. The distinctive radial ornament is sufficient to distinguish this from the similar *Petrocrania* sp. found in abundance at the same locality, which has an ornament concentric to the apex. It also separates it from *Philhedrella*, which is very similar internally to *Philhedra* and *Petrocrania* but has no radial ornament. Although no interiors are positively assigned to *Philhedra*, there is a possibility that some of the specimens counted as *Petrocrania* in the total counts at Kildare may in fact belong to *Philhedra* sp. However, the distinctions between the genera are complicated by the inadequately known type species, discussed by Wright (1963: 251). Pending a future revision of the three craniid genera, the specimen is best assigned to *Philhedra*. Wright (1970) recorded neither *Petrocrania* nor *Philhedra* from Kildare.

Class **ARTICULATA** Huxley, 1869
Order **ORTHIDA** Schuchert & Cooper, 1932
Superfamily **ORTHOIDEA** Woodward, 1852
Family **ORTHIDAE** Woodward, 1852
Subfamily **ORTHINAE** Woodward, 1852
Genus ***ORTHAMBONITES*** Pander, 1830

'Orthambonites' spp. Pl. 3, figs 1–5

Material and localities. Kildare, Grange Hill, Horizon 1: 6 internal moulds of brachial valves, 2 internal moulds and 2 external moulds of pedicle valves, both incomplete. Kilbride: 8 internal and 1 external moulds of pedicle valves, 14 internal and 3 external moulds of brachial valves.

Measurements (mm)

	X1	X2
Pl.3, fig. 1.	10·5	12·6
Pl.3, fig. 2	4·0	4·6
Pl.3, figs 3, 4	6·6	9·0
Pl.3, fig. 5	5·2	7·3

Discussion. The small samples are inadequate to justify assignment to any species and in any case the taxonomy of '*Orthambonites*' is in need of revision.

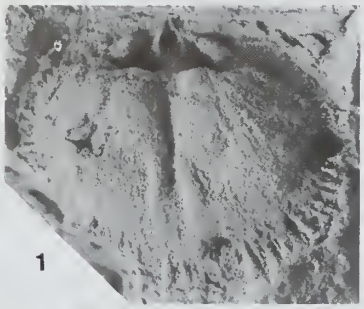
Subfamily **PRODUCTORTHINAE** Schuchert & Cooper, 1931
Genus ***NICOLELLA*** Reed, 1917

Nicolella cf. ***actoniae*** (J. de C. Sowerby, 1839) Pl. 3, figs 6–9, 11

Material and localities. Kilbride: 10 internal and 8 external moulds of pedicle valves, 6 external moulds of brachial valves; all material is fragmentary. Carrigadaggan: 3 internal and 8 external moulds of pedicle valves, 1 internal and 5 external moulds of brachial valves; material is mostly fragmentary. Greenville-Moyne: 3 internal and 7 external moulds of brachial valves, 3 internal and 4 external moulds of pedicle valves and 1 conjoined internal mould. Kildare, Grange Hill, Horizon 1: 1 internal and 1 external mould of a brachial valve.

Discussion. Williams (1974: 58) commented on the morphological stability of *Nicolella actoniae* from mid Caradoc to early Ashgill times. All the samples here are probably very close to *N. actoniae*, or the subspecies *N. actoniae obesa* Williams (1963) from Bala, North Wales, a much deeper form than the nominate subspecies. All the samples collected here are poorly preserved and mostly broken, as well as relatively small in numbers; hence measurements of variation and counts of rib numbers are not possible. Thus assignment to one species, or several, is unrealistic until larger samples are available to assess the variation in morphology.

The Greenville-Moyne sample is apparently not as deep in the ventral valve as that from Carrigadaggan or Kilbride, but this may be a preservational effect, owing to disparity in compaction between the fine-grained mudstones of Greenville-Moyne, and the coarse volcaniclastics of Carrigadaggan or the tuffaceous siltstones of Kilbride. The latter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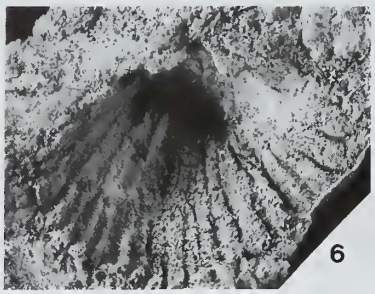
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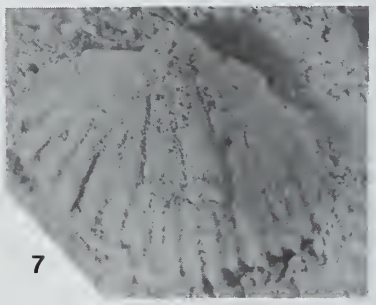
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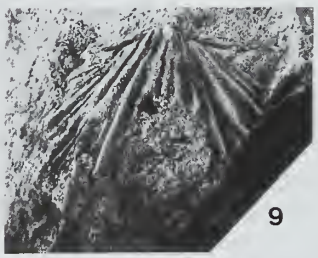
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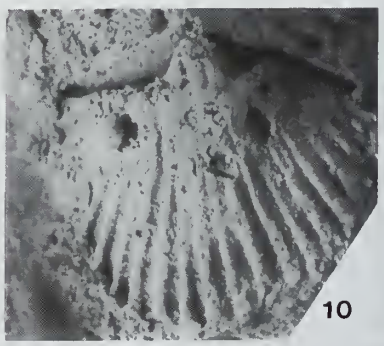
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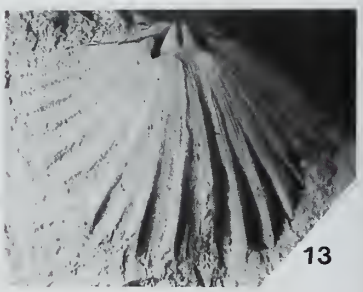
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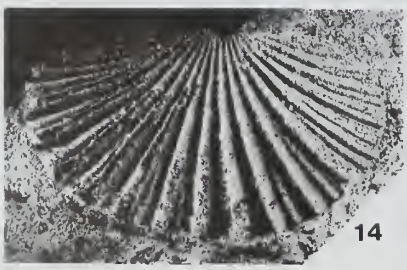
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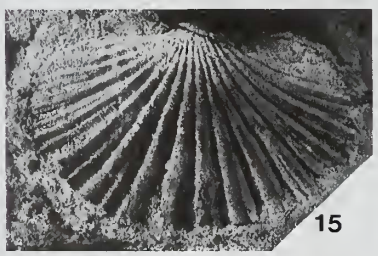
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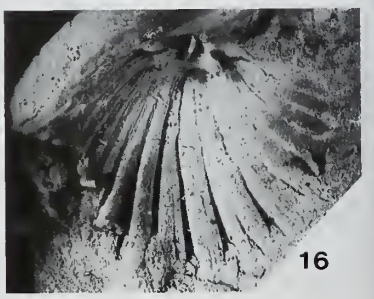
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two samples are strongly convex in the pedicle valve and appear most similar to *N. actoniae obesa*, from the Gelli-grin Formation of the Bala district. The broken nature of the samples, particularly of the Kilbride one (as are most species from there), generally precluded counts of rib numbers, but three brachial valve external moulds from Kilbride had 10, 12 and 15 ribs, and one pedicle valve had 11 in total.

Type specimens of *N. interplicata* (M'Coy, 1846), from the Kildare Limestone Formation, were examined (NMI-lectotype F4565, paralectotypes F5564 and F11604), but they are inadequate for formal comparison. Indeed the latter specimen is probably not a *Nicolella* at all. As noted by Cocks (1978) the evaluation of topotypes from the Kildare Limestone Formation is necessary to assess this species. Whether *Nicolella calcarata* M'Coy (1846), cited as rare in the slates of Greenville and very common in the slates of Slieveroe, Rathdrum, is simply a deformed version of *N.* cf. *actoniae* or a separate species is not clear, since no Greenville topotypes were recovered. The lectotype (F4567) is broken and did not appear similar to any of the samples, being more transverse and coarsely costate. A paralectotype (F5509) from Slieveroe is also deformed and broken but appears similar to *N.* cf. *actoniae*.

Larger collections of better-preserved material would be desirable to enable both a biometric comparison with *N.* cf. *actoniae* and described subspecies as well as pre-Longvillian species such as *N. humilis* (Whittington & Williams 1955) and *N.* cf. *strasburgensis* (Williams 1962). Provisionally, the present material is compared to *N. actoniae* which, as presently understood, encompasses a wide range of variation and a lengthy time span (mid Caradoc – mid Ashgill).

Nicolella ? sp. Pl. 3, fig. 12

MATERIAL AND LOCALITY. Kilbride: 1 internal and external mould of a brachial valve.

DISCUSSION. This single concave brachial valve is questionably assigned to *Nicolella*, but is different from the other samples of the genus, including the Kilbride material, principally in being large and having a much greater ribbing frequency (at least 26 ribs). The brachial interior has the erect cardinal process, short divergent brachiophores and heavy deposits of secondary shell ankylosing the brachiophores to a short median ridge which are characteristic of *Nicolella*. It may possibly be compared to *N. asteroidea* Reed, which has more ribs than *N. actoniae*, but the preservation of the specimen is inadequate to assess the branching pattern of costellae.

Family **DOLERORTHIDAE** Öpik, 1934
Subfamily **HESPERORTHINAE** Schuchert & Cooper, 1931
Genus ***HESPERORTHIS*** Schuchert & Cooper, 1931

Hesperorthis sp. Pl. 3, fig. 10

MATERIAL AND LOCALITY. Kilbride: 3 internal moulds of pedicle valves.

DISCUSSION. The small numbers of the genus are inadequate for specific determination, but the long apsacline interarea and overall shape suggest the specimens belong to *Hesperorthis*. The genus is known from the Caradoc rocks of Grangegeeth, as the Estonian species *H. inostranzefi*, but the Kilbride species is dissimilar and much smaller. Two species are known from Girvan (Williams 1962) and one from the Llanvirn of Wales (Lockley & Williams 1981), but formal comparison requires a better preserved and larger sample from Kilbride.

Family **PLAESIOMIIDAE** Schuchert, 1913
Subfamily **PLAESIOMIINAE** Schuchert, 1913
Genus ***PLAESIOMYS*** Hall & Clarke, 1892

Plaesiomys multiplicata Bancroft, 1945
Pl. 3, figs 13–16; Pl. 4, figs 1–6; Pl. 7, fig. 12

? 1896 *Orthis flabellulum* Sowerby; Reynolds & Gardiner: 589.
1945 *Dinorthis* (*Plaesiomys*) *multiplicata* Bancroft: 244; pl. 35, figs 4–6; pl. 36, figs 1–3.
1968 *Dinorthis multiplicata* Bancroft; Diggens & Romano: 47; pl. 5, fig. M.
1978 *Plaesiomys multifida* (Salter); Cocks: 50 (*pars*).
1978 *Dinorthis multiplicata* Bancroft; Brenchley: 160.
1980b *Lordorthis* sp.; Mitchell, *in* Romano: 206.
cf. 1985 *Plaesiomys* cf. *multiplicata* Bancroft; Harper *et al.*: 291; figs 6–24.

MATERIAL AND LOCALITY. Kildare, Grange Hill House Cottage: 26 internal and 12 external moulds of pedicle valves; 13 internal and 20 external moulds of brachial valves.

DESCRIPTION. *Exterior*. Large, dorsibiconvex to convexiplane valves of rounded subquadrate outline, with maximum width just anterior of hinge line, and about two-thirds as long as wide. Evenly convex anterior and lateral profiles in brachial valve, but pedicle valve flat to weakly concave except for swollen posterior axial surface. Ventral interarea flat and apsacline with open delthyrium. Dorsal interarea flat and orthocline, with open notothyrium. Radial ornament of evenly rounded costae and costellae and interspaces, and

PLATE 3

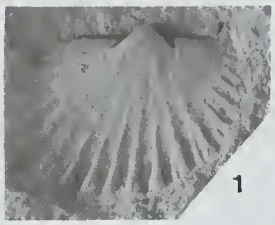
Figs 1–5 *'Orthambonites'* spp. **1, 3–4** Kildare, Grange Hill Horizon 1. **1**, BC 12658, internal mould of brachial valve, × 4. **3, 4**, BC 12660, internal mould of brachial valve, latex cast and mould, × 4. Figs **2, 5** Kilbride. **2**, BC 12659, internal mould of brachial valve, × 4. **5**, BC 12661, internal mould of pedicle valve, × 4.

Figs 6–9, 11 *Nicolella* cf. *actoniae* (J. de C. Sowerby). **6–7, 9** Kilbride. **6, 7**, BC 12662, internal mould of pedicle valve, latex cast and mould, × 4. **9**, BC 12664a, internal mould of pedicle valve, × 2. Figs **8, 11** Greenville-Moyne. **8**, BC 12663b, external mould of pedicle valve, × 2. **11**, BC 12663a, internal mould of pedicle valve, counterpart of Fig. 8, × 2.

Fig. 10 *Hesperorthis* sp. Kilbride. BC 12666, internal mould of pedicle valve, × 10.

Fig. 12 *Nicolella*? sp. Kilbride. BC 12665b, external mould of brachial valve, × 2.

Figs 13–16 *Plaesiomys multiplicata* Bancroft. Kildare, Grange Hill House Cottage. **13, 16**, BC 12667, internal mould of brachial valve, and latex cast, × 4. **14, 15**, BC 12668, external mould of pedicle valve, and latex cast, × 4.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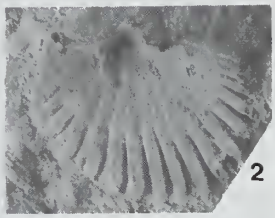
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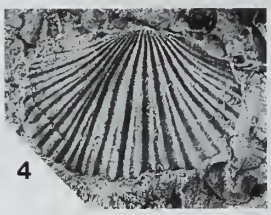
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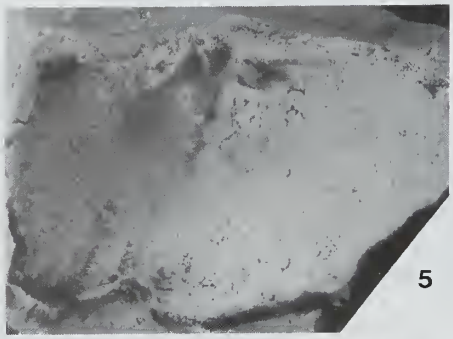
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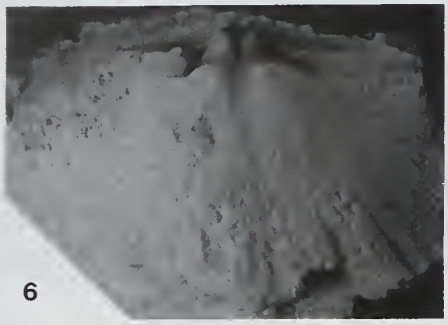
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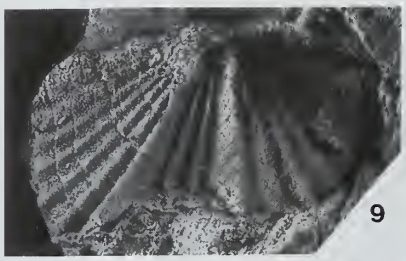
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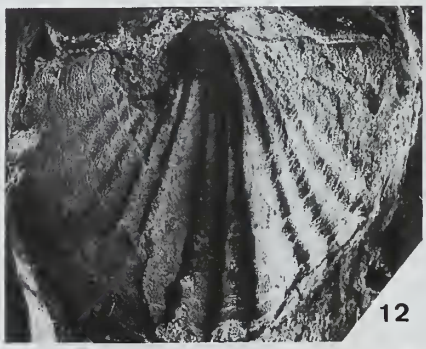
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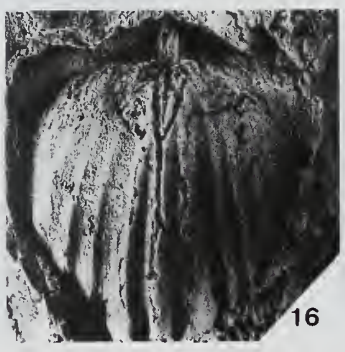
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very fine concentric growth lines. Counts of 18–25 costae and costellae are present on 2, 0, 0, 1, 1,1, 0 and 1 valve exteriors at the 5 mm growth stage and counts of 27 and 31 costae and costellae on 2 and 1 valve exteriors at the 10 mm growth stage.

Ventral interior. Stout, small teeth directed dorsilaterally from anterior margins of wide delthyrium are supported by strong receding dental plates. External ornament strongly impressed, particularly near anterior margins.

Dorsal interior. Simple, linear cardinal process is slightly thickened posteriorly, situated on notothyrial platform which extends anteriorly for one-third of valve length as a low broad ridge. Blade-like, divergent brachiophores supported by stout bases which, with the hinge line, define deep sockets.

Discussion. Although large, the sample cannot easily be statistically compared to the existing descriptions of the species because many of the specimens are broken or poorly preserved. However, sufficient distinctive material is described to assign it confidently to the species illustrated by Bancroft (1945) from the Soudleyan of Glyn Ceiriog, North Wales, and in particular the sample described by Harper & Mitchell (Harper *et al.*, 1985) from the Clashford House Formation of Co. Meath. Re-collection of more specimens will allow a better assessment of the variability in the species, particularly in external ornament, since the available material shows a few specimens more like the closely related genus *Dinorthis*, than like *Plaesiomys*. The relationship of these two genera is in need of reassessment. However, the record of *Orthis flabellulum* from here (Reynolds & Gardiner 1896) is probably the present species. Lamont (1953) noted that it was 'apparently a late variety of J. de C. Sowerby's species with bifurcation and trifurcation of ribs'. The specimens collected by Lamont are now held in the National Museum of Ireland, but were apparently never figured or described. They are labelled as '*Dinorthis peplos*' on Lamont's labels, but no publication of this name is known.

Family **PLECTORTHIDAE** Schuchert & Le Vene, 1929
Subfamily **PLATYSTROPHINAE** Schuchert & Le Vene, 1929
Genus ***PLATYSTROPHIA*** King, 1850

Platystrophia sp. 1 Pl. 4, figs 7–17; Pl. 5, figs 1–3

Material and localities. Kildare, Grange Hill, Horizon 1: 30 internal and 17 external moulds of pedicle valves; 33 internal and 13 external moulds of brachial valves; 6 internal and 10 external conjoined moulds; 12 external fragments. Most of the material assigned to *Platystrophia* is incomplete. Kildare, Grange Hill, Horizon 2: 1 conjoined shell and one brachial valve.

Discussion. Although the large sample of specimens from Grange Hill, Kildare, was clearly identifiable as *Platystrophia* in both internal and external moulds, the material is almost all fragmentary or partially broken, precluding valid measurements. A statistical assessment was not possible. Since *Platystrophia* is a ubiquitous genus in Middle and Upper Ordovician rocks in Europe and America, with little variation amongst the many described species, it is necessary to reiterate the need for a complete species revision. Many authors such as Williams (1962: 126; 1963: 371), Wright (1964: 206), Cocks (1978: 55) and Hiller (1980: 143) have discussed the artificial nature of Cumings' (1903) scheme of species groupings, elaborated further by McEwan (1920) and modified in terminology by Schuchert & Cooper (1932: 67). In this scheme, the present material is all placed in the bicostate group, with 2 costae in the ventral sulcus and 3 on the dorsal fold. The counts on suitable material showed there were 1, 5, 3 and 2 pedicle valves with 4, 5, 6 and 7 costae respectively, on each flank.

The Kildare population is finely pustulose, but distinguishing it from other species is a concentric ornamentation inviting comparisons with *P. caelata* Williams from the Soudleyan of Shelve, Shropshire (Williams 1974: 76–77; pl. 12, figs 13, 14, 16–19). The ornament is of differentially developed lamellae, but further investigation would be needed to assess whether the lamellae are of the distinctive *P. caelata* type or merely accentuated growth lines. In his description Williams stated that *P. caelata* is uniplicate, but later noted all specimens are biplicate (bicostate); this would appear to be correct from the figures.

Platystrophia sp. 2 Pl. 5, figs 4, 5

Material and locality. Kilbride: 1 external and 3 internal moulds of brachial valves; 1 internal and 1 external moulds of pedicle valves, all incomplete.

Discussion. The present material is inadequate for specific determination but appears to differ from *Platystrophia* sp. 1 from Kildare, Grange Hill in having 7 ribs on the ventral flanks, although being of smaller average size. It also lacks the strongly developed overlapping lamellae, although in other respects it is similar, belonging to the bicostate group.

Subfamily **RHACTORTHINAE** Williams, 1963
Genus ***RHACTORTHIS*** Williams, 1963

Rhactorthis sp. Pl. 5, figs 6–11

Material and locality. Kildare, Grange Hill, Horizon 1: 4 internal and 2 external moulds of brachial valves, 2 external moulds of pedicle valves and 1 conjoined internal and external mould.

PLATE 4

Figs **1–6** *Plaesiomys multiplicata* Bancroft. Kildare, Grange Hill House Cottage. **1, 2,** BC 12669, internal mould of pedicle valve, and latex cast, × 4. **3, 4** BC 12670, external mould of brachial valve, latex cast and mould, × 2. See also Pl. 7, fig. 12. **5, 6,** BC 12671, internal mould of brachial valve, latex cast and mould, × 4.

Figs **7–17** *Platystrophia* sp. 1. Kildare, Grange Hill Horizon 1. **7,** BC 12672, internal mould of pedicle valve, × 2. **8,** BC 12673, latex cast of external mould of brachial valve, × 4. **9,** BC 12674, latex cast of external mould of pedicle valve, × 4. **10,** BC 12675, latex cast of external mould of pedicle valve, × 2. See also Pl. 5, fig. 2. **11, 17,** BC 12676, internal mould and latex cast of brachial valve, × 4. **12, 15,** BC 12677, external mould and latex cast of brachial valve, × 4. See also Pl. 5, fig. 1. **13,** BC 12678a, internal mould of pedicle valve, × 2. **14,** BC 12679, latex cast of external mould of brachial valve, with a *Petrocrania* attached, × 2. **16,** BC 12680a, internal mould of brachial valve, × 4.


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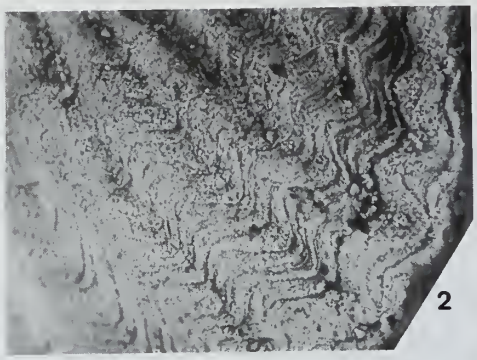
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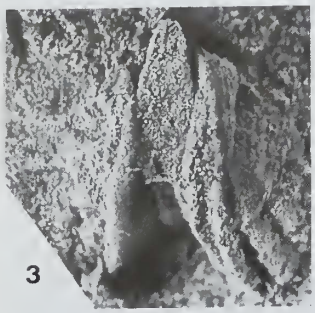
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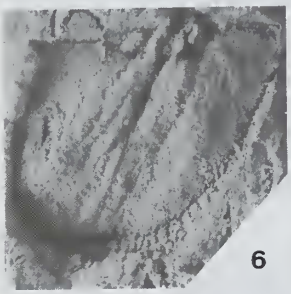
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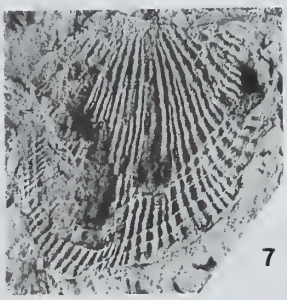
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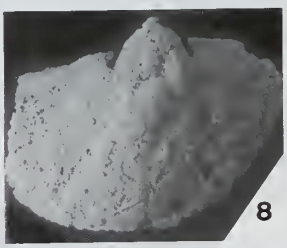
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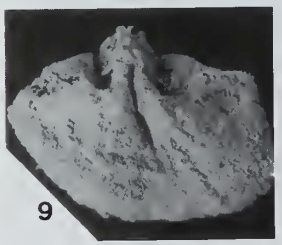
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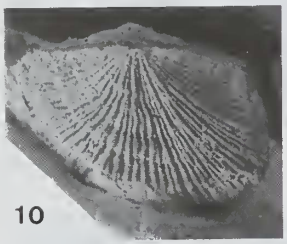
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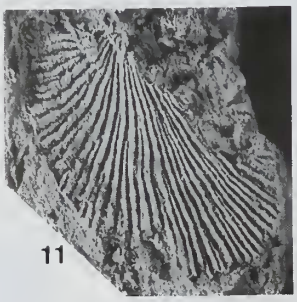
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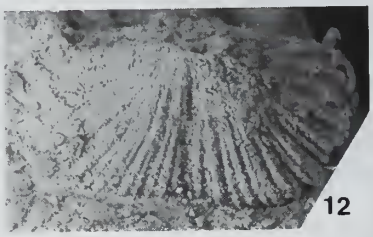
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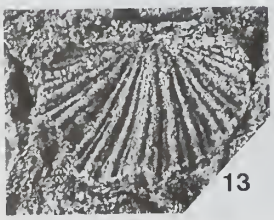
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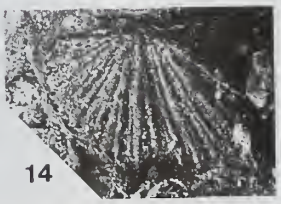
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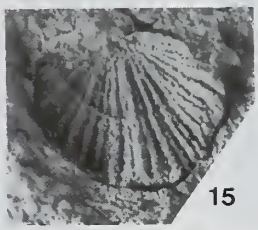
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16

MEASUREMENTS (mm)

	X1	X2	X3	
Pl.5, figs 8,9	8·1	10·4	3·1	(conjoined internal mould)
Pl.5, fig.10	8·2	11·1	4·1	(brachial valve)
Pl.5, figs 6,11	9·8	9·5	–	(strained brachial valve)

DISCUSSION. The sparse numbers of this genus from Kildare are inadequate to justify assignment, either to the type species *R. crassa* Williams from the Longvillian of Bala, or to either of the other Caradoc species *actoniae* and *grandis* erected by Hurst (1979*a*), from the type Caradoc of Shropshire. Its presence, however, serves to emphasize the similarities of the Kildare fauna to that of the Bala district of North Wales.

Family **CREMNORTHIDAE** Williams, 1963
Subfamily **CREMNORTHIDAE** Williams, 1963
Genus ***CREMNORTHIS*** Williams, 1963

Cremnorthis parva Williams, 1963
Pl. 5, figs 12–16; Pl. 6, figs 1–7

1963 *Cremnorthis parva* Williams: 379; pl. 4, figs 15–23; text-fig. 9.

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 1: 38 internal moulds of brachial valves, 31 internal moulds of pedicle valves; 14 external moulds of brachial valves, 7 external moulds of pedicle valves. Carrigadaggan: 3 internal and 1 external moulds of pedicle valves, 3 internal moulds of brachial valves. Kilbride: 9 internal and 1 external moulds of pedicle valves, 6 internal moulds of brachial valves. Greenville-Moyne: 8 internal moulds of pedicle valves and 2 internal moulds of brachial valves.

DESCRIPTION. *Exterior.* Subcircular to semicular outline, moderately biconvex, with both valves about three-tenths as deep as long. Maximum width occurring at less than one-third the length of the shell. Length of brachial valve about seven-tenths of the width. Pedicle valve length about four-fifths of width. Brachial valve gently sulcate, with flatly convex lateral profile. Dorsal interarea short and anacline, ventral interarea apsacline and about a quarter the length of the valve. Radial ornamentation costellate with angular costae and costellae about 5 per mm at 2 mm anterior of umbones. Shell impunctate.

Ventral interior. Short teeth connected to shell floor by thickened deposits, and long apsacline interarea, which together bound a deep umbonal cavity. Subtriangular muscle scar does not extend much beyond cavity anteriorly. Muscle field composed of wide median adductor scars flanked by pair of narrow diductor scars which are lobate anteriorly. Sagittal length of muscle field nearly two-fifths length of valve.

Dorsal interior. Large cardinal process, standing above hinge line, is continuous with blade-like median septum which extends four-fifths of the valve length, and is highest at about mid-length. Brachiophores short and slightly divergent, continuous with bases which curve posterolaterally as fulcral plates to define subtriangular sockets. Brachiophore bases are situated at about a quarter of the valve length.

MEASUREMENTS

Pedicle valve internal moulds (Kildare, Horizon 1):

Variates	X1	X2	X3	X4	X5	X6	X9	X10
Means	3·31	3·39	1·22	0·96	2·84	0·96	1·33	1·08
Sample size	29	30	30	29	19	19	26	25
Variance-covariance Matrix	0·50	0·39	0·21	0·10	0·23	0·04	0·20	0·14
		0·57	0·14	0·08	0·36	0·04	0·14	0·14
			0·18	0·05	0·09	0·03	0·13	0·08
				0·05	0·06	0·01	0·04	0·03
					0·39	0·03	0·08	0·08
						0·02	0·03	0·02
							0·14	0·08
								0·07

Brachial valve internal moulds (Kildare, Horizon 1):

Variates	X1	X2	X3	X4	X17	X18	X24
Means	3·07	3·44	1·13	0·87	0·77	1·28	2·54
Sample size	38	37	36	35	35	35	38
Variance-covariance Matrix	0·46	0·38	0·14	0·08	0·08	0·10	0·33
		0·76	0·09	0·10	0·08	0·15	0·26
			0·10	0·01	0·03	0·02	0·01
				0·04	0·01	0·03	0·06
					0·03	0·03	0·06
						0·06	0·08
							0.30

DISCUSSION. The numerical data in the description are based only on the mean values for the large sample from Grange Hill, Kildare, where this species is a very common element of the fauna. The poor preservation of the samples from Kil-

PLATE 5

Figs 1–3 *Platystrophia* sp. 1. Kildare, Grange Hill Horizon 1. **1**, BC 12677, detail of ornament of latex cast, × 10. See also Pl. 4, figs 12, 15. **2**, BC 12675, detail of ornament of latex cast showing the accentuated lamellae, × 10. See also Pl. 4, fig. 10. **3**, BC 12681, internal mould of pedicle valve (probably a juvenile specimen), × 10.

Figs 4–5 *Platystrophia* sp. 2. Carrigadaggan. BC 12682, internal mould of brachial valve and latex cast, × 4.

Figs 6–11 *Rhactorthis* sp. Kildare, Grange Hill Horizon 1. **6**, BC 12683a, internal mould of brachial valve, × 4. **7**, BC 12684, external mould of pedicle valve, × 4. **8, 9**, BC 12685a, ventral and dorsal views of a conjoined internal mould, × 4. **10**, BC 12685b, latex cast of external mould of conjoined valves, counterpart of Figs 8–9, dorsal view, × 4. **11**, BC 12683b, external mould of brachial valve, counterpart of Fig. 6, × 4

Figs 12–16 *Cremnorthis parva* Williams. Kildare, Grange Hill Horizon 1. **12**, BC 12686, latex cast of external mould of brachial valve, × 10. **13, 14**, BC 12687, external mould and latex cast of brachial valve, × 10. **15, 16**, BC 12688, external mould and latex cast of brachial valve, × 10.

Fig. 16 Palaeogeographic reconstruction of the Iapetus region in mid-Caradoc times (*c.* 448 Ma) showing the main continental masses of Laurentia, Baltica, Gondwana and Eastern and Western Avalonia. The main brachiopod provinces of Scoto-Appalachian, Baltic and Mediterranean affinity are also shown. At this time, an Anglo-Welsh Province, including these Leinster faunas, was centred on Eastern Avalonia (after Parkes, 1992).

bride and Carrigadaggan made measurement of all variates difficult, but a principal component analysis (PCA) of all three samples shows that in plots of the first four eigenvectors (see Fig. 17) the two small samples fall within the same region as the Kildare sample. It is possible that analysis of a larger topotype sample of the species would show significant differences between the Welsh and Irish forms, but the original description was based on fewer than ten valves. The mean percentage length of the ventral muscle field relative to the valve length is significantly longer in the Irish form (Kildare – 39% compared to 35%, $p < 0{\cdot}01$). This is considered inadequate to justify erection of even a new subspecies, since the Bala sample consisted of only 5 specimens. A larger, better preserved sample would probably encompass the same variation seen in the Kildare form.

PLATE 6

Figs 1–7 *Cremnorthis parva* Williams. **Figs 1–5**, Kildare, Grange Hill Horizon 1. **1**, BC 12689, internal mould of brachial valve, × 5. **2, 3**, BC 12690, internal mould of pedicle valve, latex cast and mould, × 15. **4**, BC 12691, internal mould of brachial valve, and BC 12692, internal mould of pedicle valve, both × 6. **5**, BC 12693, internal mould of brachial valve, × 3. **Figs 6, 7**, Carrigadaggan. **6**, BC 12694, ventral view of conjoined internal mould, × 10. **7**, BC 12695, internal mould of pedicle valve, × 10.

Figs 8–16 *Skenidioides costatus* Cooper. Kildare, Grange Hill Horizon 1. **8, 12**, BC 12696, dorsal and ventral views of conjoined internal mould, × 10. **9**, BC 12697, internal mould of brachial valve, × 10. **10**, BC 12698, internal mould of brachial valve, × 10. **11**, BC 12699, ventral view of conjoined internal mould, × 10. **13**, BC 12700, internal mould of pedicle valve, × 10. **14**, BC 12701, internal mould of pedicle valve, × 10. **15**, BC 12702, internal mould of pedicle valve, × 10. **16**, BC 12703, internal mould of pedicle valve, × 10.


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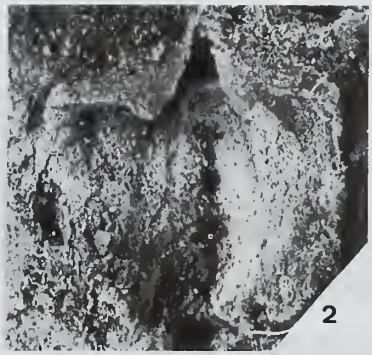
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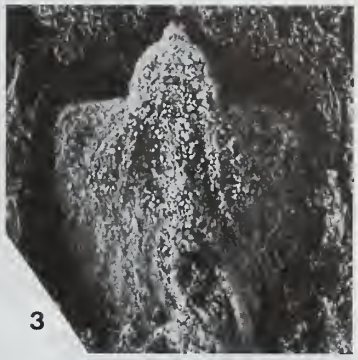
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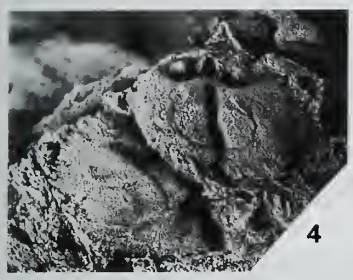
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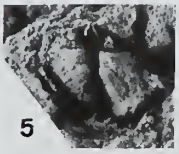
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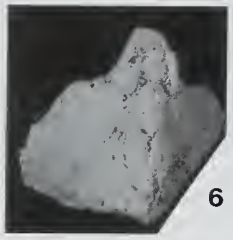
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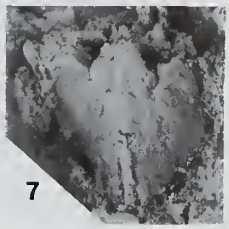
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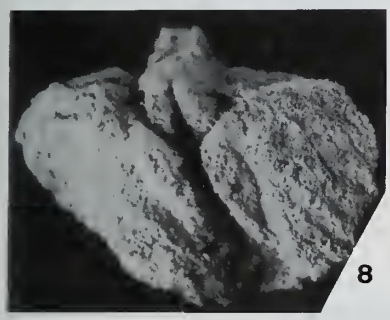
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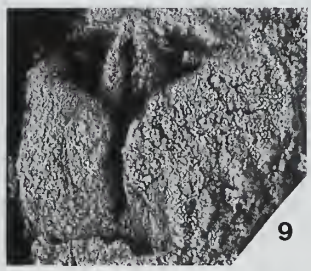
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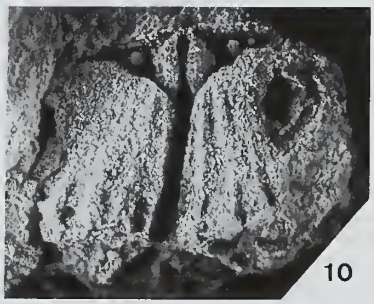
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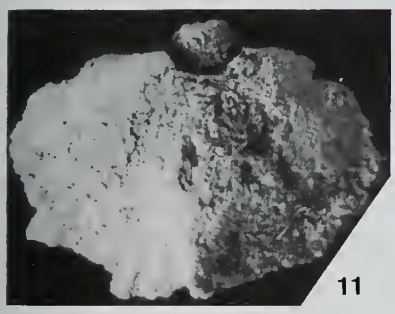
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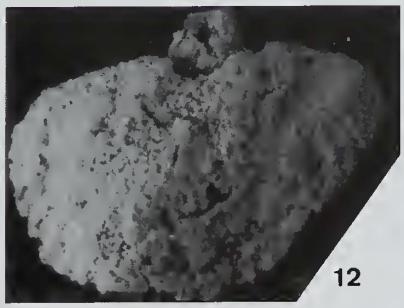
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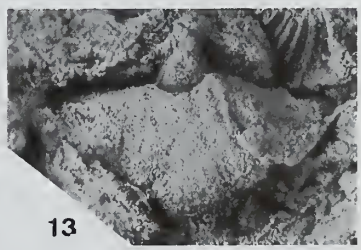
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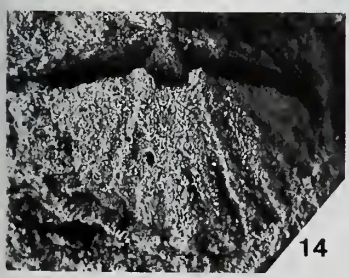
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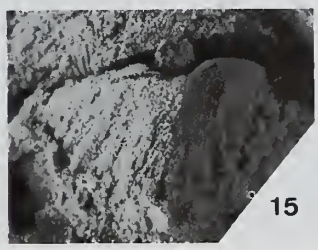
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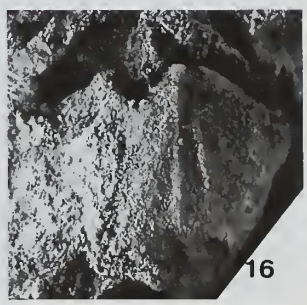
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Family **SKENIDIIDAE** Kozlowski, 1929
Genus ***SKENIDIOIDES*** Schuchert & Cooper, 1931

Skenidioides costatus Cooper, 1956
Pl. 6, figs 8–16; Pl. 7, figs 1–5

1956 *Skenidioides costatus* Cooper: 493; pl. 97, figs 38–48.
aff. 1962 *Skenidioides* aff. *costatus* Cooper; Williams: 126; pl. 11, figs 24–27, 52.
cf. 1963 *Skenidioides* cf. *costatus* Cooper; Williams: 375–377; pl. 4, figs 7–14.
cf. 1974 *Skenidioides* cf. *costatus* Cooper; Williams: 82–83; pl. 13, figs 14–16; pl. 14, figs 1–3.
cf. 1979a *Skenidioides* cf. *costatus* Cooper; Hurst: 242; figs 145–159.

MATERIAL AND LOCALITIES. Kilbride: 2 internal and 3 external moulds of pedicle valves; 3 internal and 6 external moulds of brachial valves. Kildare, Grange Hill, Horizon 1: 10 internal and 10 external moulds of brachial valves; 19 internal and 3 external moulds of pedicle valves. Kildare, Grange Hill House Cottage: 2 internal and 1 external moulds of pedicle valves; 1 internal and 2 external moulds of brachial valves. Carrigadaggan: 1 internal mould of a pedicle valve. Kildare, Grange Hill, Horizon 2: 3 internal moulds of pedicle valves. Greenville-Moyne: 1 internal and 1 external moulds of a pedicle valve.

DESCRIPTION. *Exterior*. Ventribiconvex, subpyramidal *Skenidioides* with pedicle valve length about seven-tenths of the length, and about 40% as deep as long. Brachial valve gently convex with distinct median sulcus, about 50–70% as long as wide. Ornament of radial costellae, about 2–5, commonly 3, ribs per mm 2mm anteromedially of umbo, in both valves. Commonly a wider median rib on the pedicle valve, with total rib counts of between 12 and 20 with 15–17 the most common frequency. Ventral interarea high, catacline to apsacline with open delthyrium. Dorsal interarea shorter, anacline.

Ventral interior. Generally unsupported spondylium about a quarter as long as the valve, and about 94% as long as wide. Some shells have a median thickened ridge of shell supporting the spondylium.

Dorsal interior. Thin median septum, continuous anteriorly from shaft-like cardinal process, extending about 90% of valve length. Slender brachiophores with bases convergent onto median septum defining a diamond shaped cruralium about a third as long as valve.

DISCUSSION. Previously described samples compared to *S. costatus* (Cooper 1956) differ in some proportions from each other and from the material described here, but the differences are not considered important enough to warrant taxonomic recognition. Principal component analysis of all the material shows no differentiation on the first four vectors, as shown in Fig. 18. As noted by Mitchell (1977: 50) and Hiller (1980: 146), internal features of many *Skenidioides* species show no significant differences, the species being separated on the basis of the density of external ornament. The rib counts for this Irish material is comparable to previously described populations of *S. costatus* of similar size range.

One aspect which apparently requires further investigation is the branching mode of the ribs of the species. Williams (1974: 83) discussed the differences between Shelve and Bala stocks, with new costellae arising only from the ventral median rib in the former and branching freely from lateral costae in the latter. In the Bala stocks, the majority of costae branched externally (Williams 1963: 377). However, Hurst (1979*a*: 242) states that the Shropshire stock only branched

MEASUREMENTS
Pedicle valve internal moulds (Kildare, Horizon 1):

Variates	X1	X2	X4	X13	X14
Means	3·37	4·64	1·29	0·81	0·84
Sample size	19	19	19	18	18
Variance-covariance	0·46	0·42	0·06	0·13	0·06
Matrix		0·77	0·05	0·10	0·08
			0·08	0·01	0·01
				0·06	0·03
					0·02

Brachial valve internal moulds:

Variates	X1	X2	X15	X16	X24
Means	3·00	4·11	0·98	0·83	2·76
Sample size	10	10	10	10	10
Variance-covariance	0·25	0·24	0·06	0·02	0·26
Matrix		0·78	0·02	0·10	0·14
			0·03	0.0	0.06
				0·02	0·0
					0·32

Brachial valve external moulds:

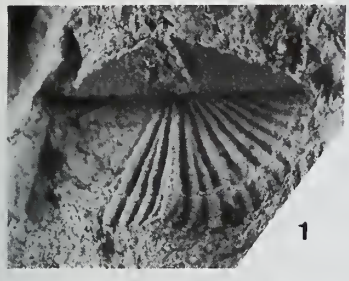
Variates	X1	X2	X4
Means	2·73	5·32	0·47
Sample size	10	10	7
Variance-covariance	0·43	0·63	0·05
Matrix		1·17	0·14
			0·12

PLATE 7

Figs 1–5 *Skenidioides costatus* Cooper. Kildare, Grange Hill Horizon 1. **1, 3**, BC 12704, external mould of brachial valve and interareas, × 6, and enlarged oblique posterior view of latex cast of interareas, showing hinge line and open delthyrium and notothyrium, × 10. **2**, BC 12809, latex cast of external mould of pedicle valve, × 6. **4, 5**, BC 12705, external mould of brachial valve and interareas, and latex cast showing open delthyrium, × 10.

Figs 6–11 *Oanduporella* cf. *reticulata* Hints. Kildare, Grange Hill House Cottage. **6, 9**, BC 12706, external mould of pedicle valve, latex cast and mould, × 10. **7, 8**, BC 12707a (upper) and BC 12708a (lower); internal moulds and latex cast of 2 pedicle valves, × 4. **10**, BC 12711b, external mould of pedicle valve, × 4. **11**, BC 12711a, internal mould of pedicle valve, counterpart of Fig. 10, × 4.

Fig. 12 View of slab, containing BC 12670, external mould of *Plaesiomys multiplicata* Bancroft (P; see also Pl. 4, figs 3–4), to illustrate the typical assemblage at Kildare, Grange Hill House Cottage; with *Oanduporella* cf. *reticulata* Hints (A), *Rafinesquina* sp. (B), and numerically dominant gastropods (C). × 1.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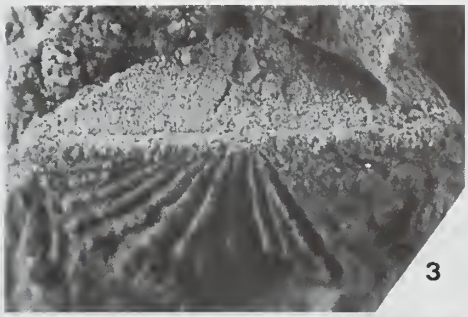
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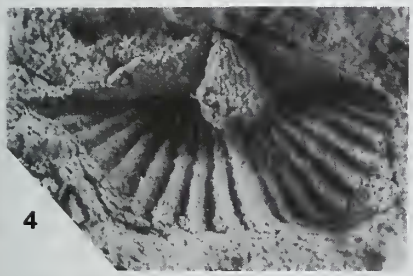
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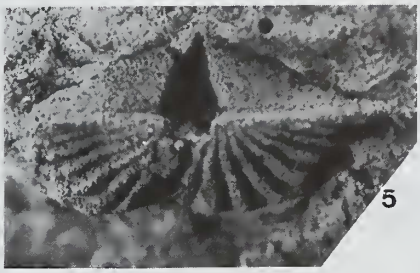
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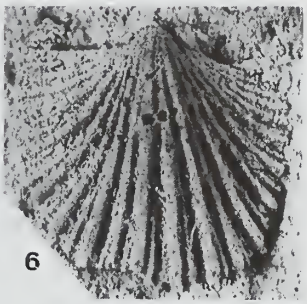
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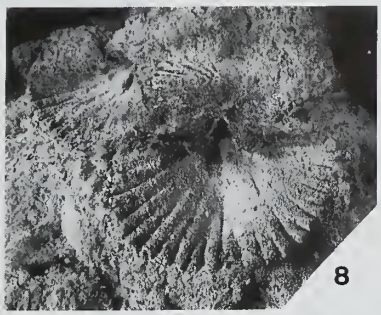
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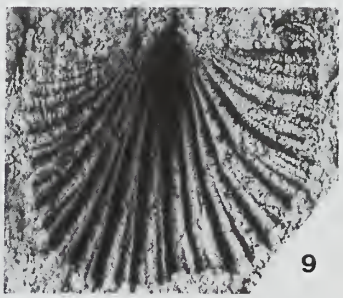
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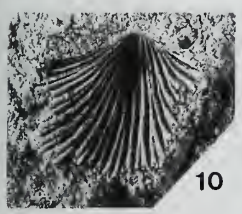
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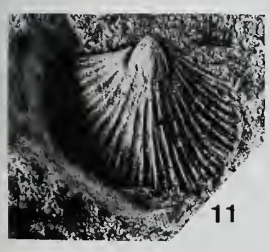
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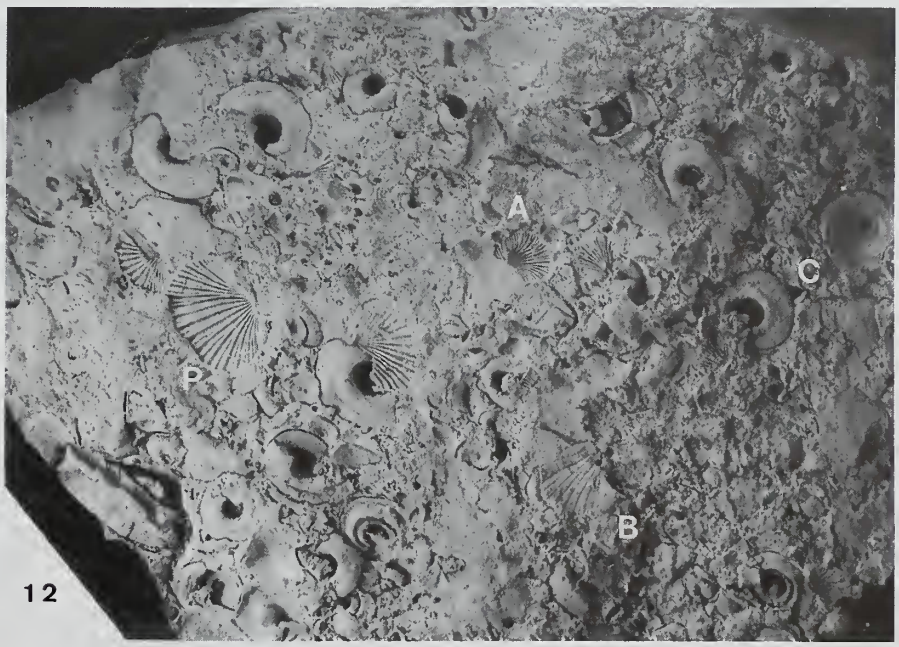

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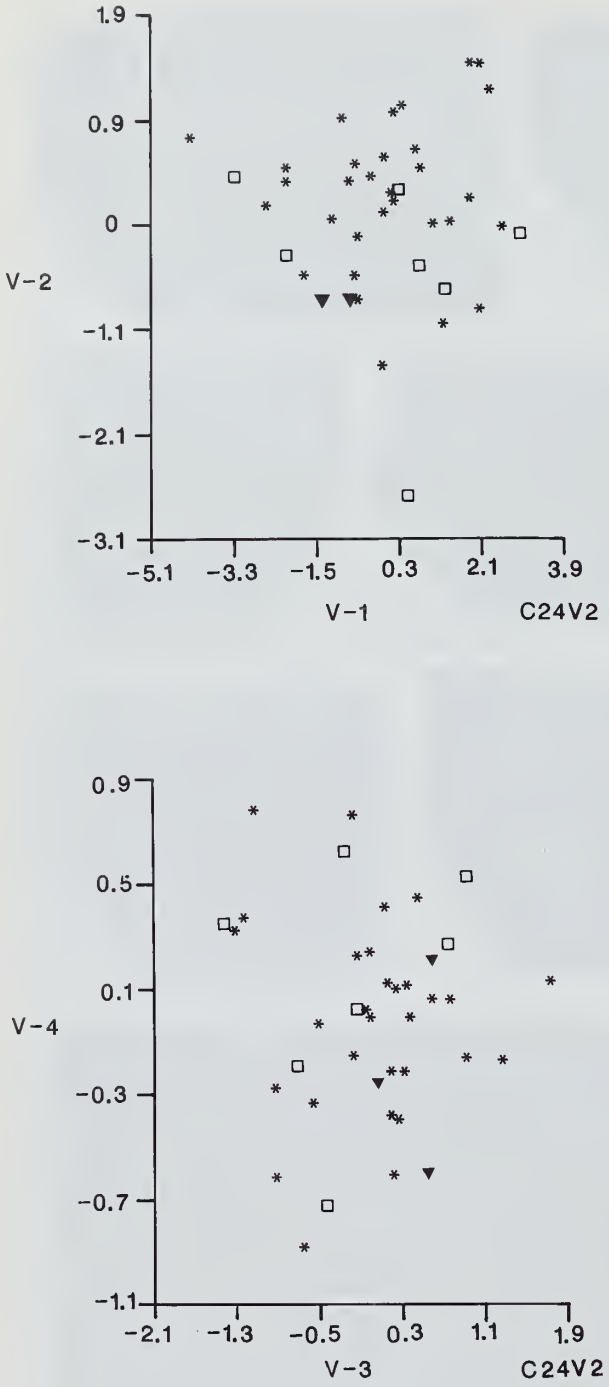


Fig. 17 Principal component analysis of samples of *Cremnorthis parva*, internal moulds of pedicle valves only. Top, vector 1 against vector 2. Below, vector 3 against vector 4. ▼ = Carrigadaggan, * = Kilbride, □ = Kildare, Grange Hill Horizon 1.

internally. The present material has few external moulds with costellae, but those that do, show both internal and external branching.

Superfamily **ENTELETOIDEA** Waagen, 1884
Family **DALMANELLIDAE** Schuchert, 1913
Genus ***OANDUPORELLA*** Hints, 1975

Oanduporella cf. ***reticulata*** Hints, 1975
Pl. 7, figs 6–12; Pl. 8, figs 1–7

cf. 1975 *Oanduporella reticulata* Hints: 19, 105; pl. 1, figs 1–15; pl. 2, figs 1–5.
1980*a*? *Ravozetina/Onnizetina*; Mitchell, *in* Romano: 206.
1985 *Oanduporella* cf. *reticulata* Hints; Harper & Mitchell, *in* Harper *et al.*: 295, figs 25–37.

MATERIAL AND LOCALITY. Kildare, Grange Hill House Cottage: 10 internal and 6 external moulds of brachial valves, 13 internal and 9 external moulds of pedicle valves.

DISCUSSION. Harper & Mitchell gave a full description (Harper *et al.*, 1985) of material they compared to Hints' species from the east Baltic, with which the present material from Kildare accords well. The Herbertstown material, from the Clashford House Formation, was the first record of the genus from Britain or Ireland and the present sample represents the second known occurrence from these areas. It serves to emphasize the similarities of the Kildare fauna to that from Herbertstown with two conspecific forms, *Plaesiomys multiplicata* Bancroft and *Oanduporella* cf. *reticulata* Hints, present, with a possible third, *Hibernodonta*? Harper & Mitchell (*in* Harper *et al.* 1985). There are few suitable specimens but similar rib counts (5–6 per 2 mm at 5 mm sagittally) are seen in the Kildare specimens, although the microsculpture is well developed on most specimens.

Oanduporella sp. (Not figured)

MATERIAL AND LOCALITY. Greenville: 3 external and 1 internal moulds of pedicle valves, 1 external mould of a brachial valve.

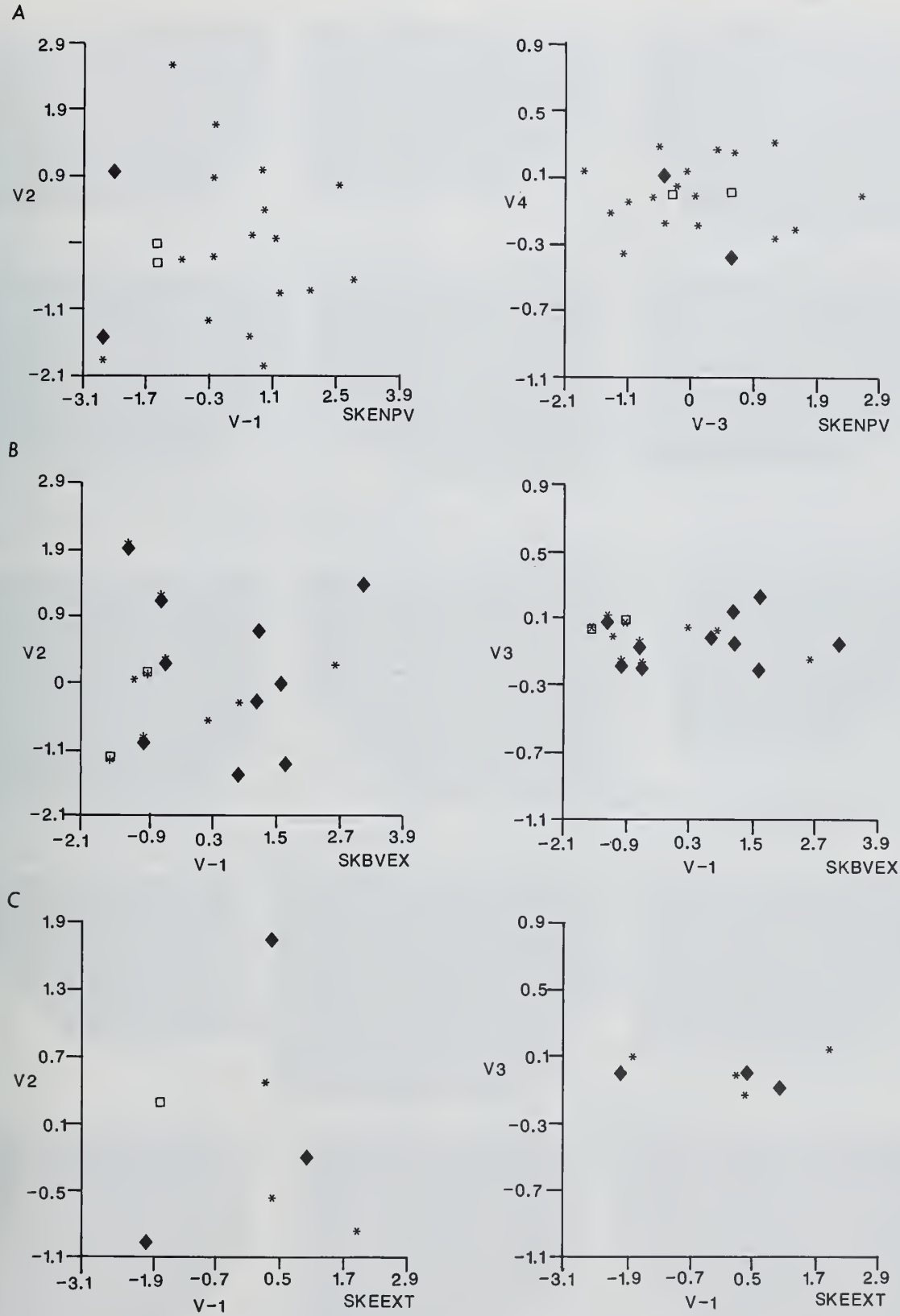
DISCUSSION. The poor preservation, and deformation in this mudstone lithology made it impossible to compare this material to the specimens from Kildare, Grange Hill House Cottage. Nevertheless, this small sample shows the characteristic pitted microsculpture of the genus and extends the known geographical range.

Genus ***REUSCHELLA*** Bancroft, 1928

Reuschella ? sp. Pl. 11, fig. 16

MATERIAL AND LOCALITY. Kilbride: A single internal mould of a pedicle valve.

DISCUSSION. The single poorly preserved mould is assigned to *Reuschella* on the basis of the sharp median carina, curved long apsacline interarea, the ventral muscle scar and massive teeth. The specimen represents the sole occurrence of the genus within the southeast Ireland Caradoc. It is known from the Actonian of Shropshire (Hurst 1979*a*), the Soudleyan of Shelve, Shropshire (Williams 1974) and Bala (Williams 1963) as well as from Girvan (Williams 1962).



ig. 18 Principal component analysis of *Skenidioides costatus*, from Kilbride (◆) and Kildare, Grange Hill House Cottage (*) and Horizon 1 (□). A, pedicle valve internal moulds; B, brachial valve external moulds; C, pedicle valve external moulds.

Family **LINOPORELLIDAE** Schuchert & Cooper, 1931
Genus ***SALOPIA*** Williams, *in* Whittington & Williams 1955

Salopia sp. Pl. 11, figs 18–20

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 2: a single internal mould of a pedicle valve. Greenville-Moyne: 4 internal and 1 external moulds of brachial valves.

DESCRIPTION. *Ventral valve*. Interior, strongly convex mould, slightly sulcate, over half as deep as long, and slightly wider than long. Maximum width just anterior to hinge line, giving a subcircular outline to shell with high apsacline, but nearly catacline interarea. Short teeth are supported by divergent dental plates. Muscle field extends beyond dental-plates to about one-third of valve length. External ornament only seen where it is impressed around margins of shell interior.

Dorsal valve. Interior, gently convex in mould form, with low notothyrial platform between divergent brachiophores carrying a thin linear shaft which is continuous with a low median septum, extending to about mid-length. External ornament impressed slightly around margins of interior.

MEASUREMENTS (mm). BC 12758: X1 = 11·5, X2 = 12, X4 = 6, X9 = 4·5 (Pl. 11, fig. 19).

DISCUSSION. *Salopia* is known from the Llandeilo (Lockley & Williams 1981: 51) and Lower Caradoc (Williams 1963, 1974; Whittington & Williams 1955) of Wales and Shropshire. The single pedicle valve from Kildare is inadequate for formal comparison, but is apparently significantly deeper than described species. The sample from Greenville-Moyne is indistinctly preserved, and is lacking in pedicle valves, so cannot be directly compared to the Kildare specimen. The closest obvious comparison is with *Salopia salteri* (Davidson, 1869).

Family **SAUKRODICTYIDAE** Wright, 1964
Genus ***SAUKRODICTYA*** Wright, 1964

Saukrodictya cf. sp. A of Hints Pl. 8, figs 8–15

cf. 1979 *Saukrodictya* sp. A, Hints: 57; pl. 2, fig. 10; pl. 4, figs 15–22.

MATERIAL AND LOCALITIES. Carrigadaggan: 1 internal and 3 external moulds of pedicle valves, 4 external moulds of indeterminate valves. Greenville-Moyne: 2 indeterminate external moulds.

DESCRIPTION. *Exterior*. Typical ornament of exopuncta, up to 6 radial rows, closely spaced, in the interspaces between narrow ribs. Interspaces are relatively wide and rounded. Ventral valve gently convex, wider than long.

Ventral interior. Nearly 50% wider than long. Gently convex profile, rectimarginate commissure. (Dorsal valve unknown).

DISCUSSION. The mould material, although very poor, is assigned to *Saukrodictya* rather than *Salacorthis* because of the typical pitted ornament found only in the interspaces and not on the thin ribs. The frequency of ribs is also greater than in *Salacorthis costellata* Williams (1974), the only known species, and the pedicle valves described here are not sulcate, as are those of *Salacorthis*.

There are a number of described species of *Saukrodictya*, but in all cases they are based on limited material and are not well known. The present material does not permit a detailed comparison with described species, but the illustrations of *Saukrodictya* sp. A by Hints (1979) from the Idavere and Johvi Stages in Estonia (L. Caradoc – *multidens* Biozone) are most similar to this material. The species apparently lacks the strong fold of *S. reticula* Vinassa, 1927 (Villas, 1985). It has a lower frequency of ribs than *S. rotundopora* Hints or *S. oblongatopora* Hints, both of which also have a fold. Similarly, *S. porosa* is sulcate and also has a greater rib frequency, though its general outline is similar (Havlíček 1977). The type species *S. hibernica* Wright (Wright 1964; see also Hiller, 1980) is strongly sulcate. However, Villas (1985) has suggested that *S. hibernica* may be conspecific with *S. reticula* (Vinassa, 1927), 'but there are too many gaps in the knowledge of 'British' and Sardinian *Saukrodictyae*'. The present sample unfortunately does nothing to clarify the definition of species, but is stratigraphically and biogeographically significant.

These are the oldest known occurrences of *Saukrodictya* in Ireland. *S. rotundopora* Hints (1979: 53) and *S. oblongatopora* Hints (1979: 55) are from approximately contemporaneous stages in the Middle Caradoc of Estonia. Other occurrences are Ashgill in age, including the type species *S. hibernica* from Portrane (Wright 1964: 216) and Wales (Hiller 1980: 165), *S. wrighti* from Belgium (Sheehan 1987) or from the Llandovery (*S.* sp. from Wales (*in* Temple, 1970: 32); *S.* sp. B from Estonia (Hints, 1979: 58)). According to Havlíček (1977) the oldest occurrence of species of *Saukrodictya* are *S. porosa* from the Liben and Letná Formations of Bohemia (Middle Llandeilo to Costonian) and in the Costonian/Harnagian of Portugal (Mitchell 1974). It would thus appear to have a Gondwanan origin and to have migrated northward, reaching Ireland by the Longvillian or earlier.

Superfamily **GONAMBONITOIDEA** Schuchert & Cooper, 1931
Family **KULLERVOIDEA** Öpik, 1934
Genus ***KULLERVO*** Öpik, 1934

Kullervo aff. *hibernica* Harper, 1952 Pl. 9, figs 1–10, 12–13

aff. 1952 *Kullervo hibernica* Harper: 100; pl. 6, figs 6–8.
aff. 1977 *Kullervo* aff. *hibernica* Harper; Brenchley *et al.*: 70.

PLATE 8

Figs **1–7** *Oanduporella* cf. *reticulata* Hints. Kildare, Grange Hill House Cottage. **1, 2**, BC 12709, external mould of brachial valve, and latex cast, × 10. **3, 4**, BC 12710a, internal mould of brachial valve, and latex cast, × 10. **5, 6**, BC 12710b, external mould of brachial valve, counterpart of Figs 3–4, latex cast, × 10. **7**, BC 12712, internal mould of brachial valve, × 72.

Figs **8–15** *Saukrodictya* cf. sp. A of Hints. Carrigadaggan. **8, 11**, BC 12713, external mould, latex cast and mould, × 10. **9, 10**, BC 12714, external mould and latex cast, × 10. **12**, BC 12715a, internal mould of pedicle valve, × 8. **13**, BC 12716b, latex cast of external mould, × 10. **14, 15**, BC 12715b, external mould of pedicle valve, counterpart of Fig. 12, latex cast and mould, × 10.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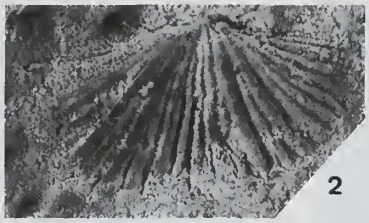
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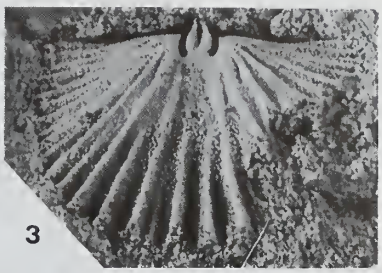
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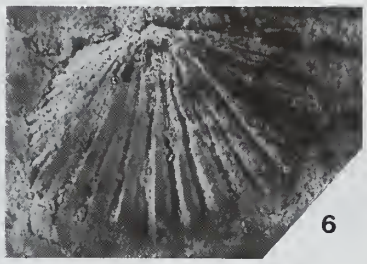
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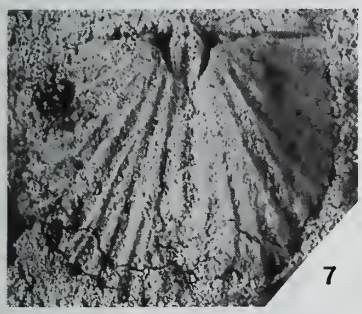
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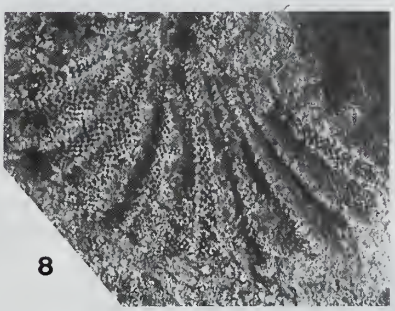
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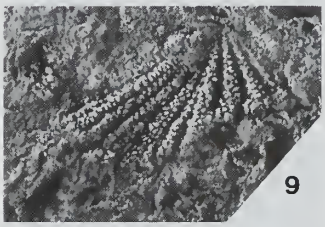
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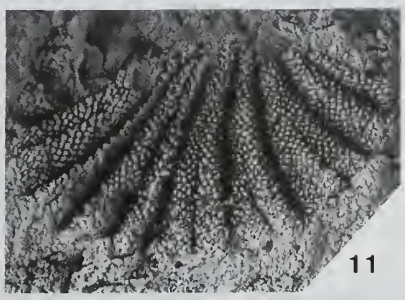
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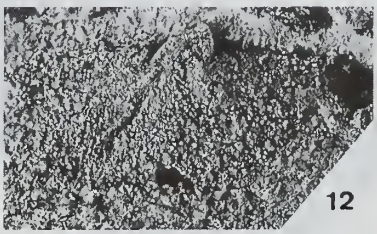
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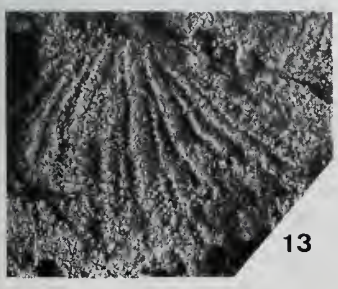
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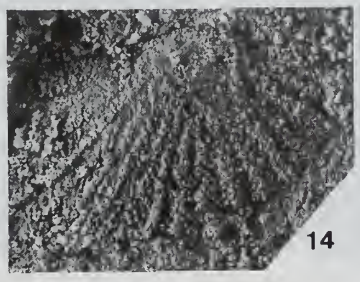
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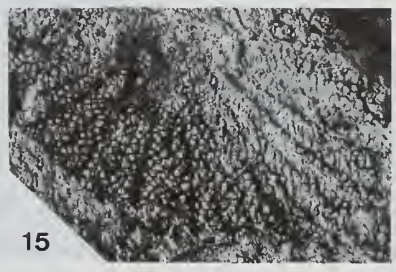
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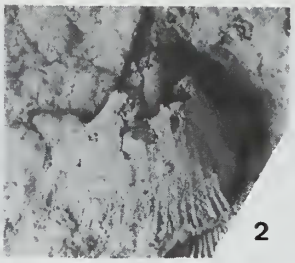
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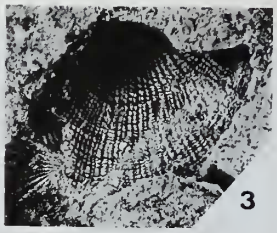
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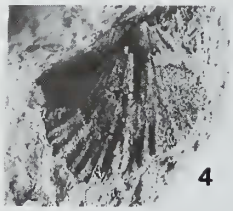
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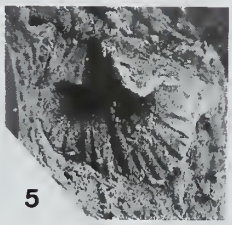
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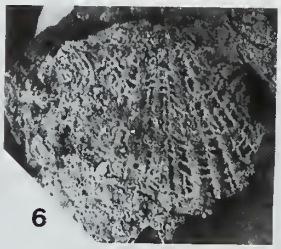
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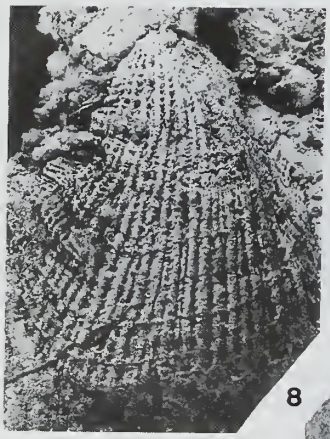
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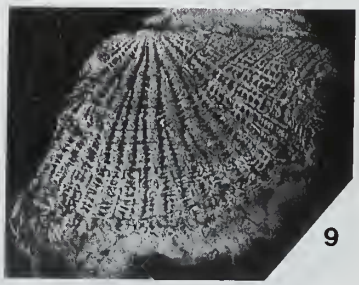
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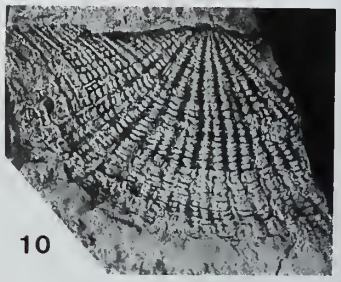
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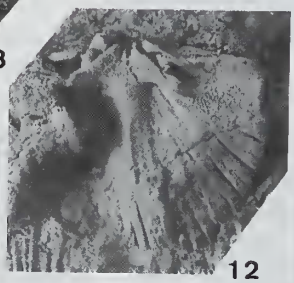
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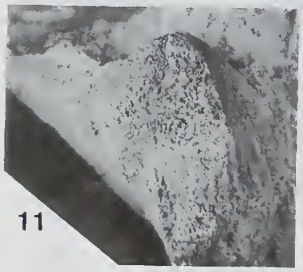
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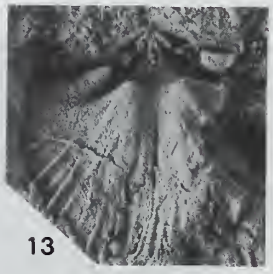
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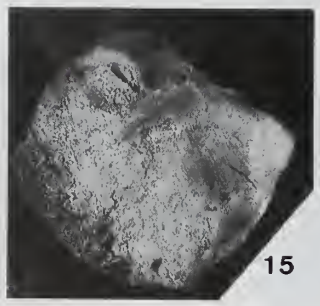
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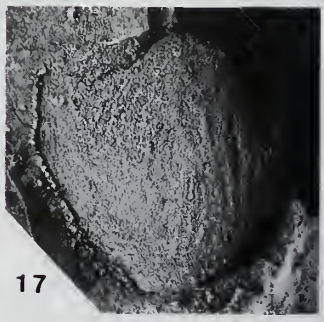
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MATERIAL AND LOCALITIES. Carrigadaggan: 3 internal moulds and 5 external moulds of pedicle valves, 2 internal and 3 external moulds of brachial valves and 8 indeterminate external moulds. Kildare, Grange Hill, Horizon 1: 1 external mould of a pedicle valve and2 fragments of internal moulds of pedicle valves. Greenville-Moyne: 3 internal and 3 external moulds of pedicle valves, 2 external moulds of brachial valves, and 2 indeterminate external moulds.

DESCRIPTION. *Exterior.* Strongly ventribiconvex *Kullervo* with pyramidal pedicle valve and maximum width along hinge line. Concave posterolateral flanks on extended hinge line, anterior slope evenly convex. Shallow median sulcus in brachial valve, but essentially rectimarginate commissure. Ventral interarea high, curved, apsacline near umbo, catacline near hinge. Dorsal interarea short, anacline. Ornament of distinctive reticulate pattern, of strongly developed concentric lamellae and regular radial ribs. Radial ornament absent on posterolateral flanks.

Ventral interior. Spondylium with hemisyrinx supported by well-developed median septum extending nearly to mid length. External ribs impressed on anterior margins of valve interior.

Dorsal interior. Cardinalia of thick divergent socket ridges about three times as long as wide, extending less than half valve width. Thin cardinal process in narrow space between their ends. Socket ridges merge anteromedially with thick notothyrial platform, itself passing into thick median ridge anteriorly. At about mid-length of valve the ridge tapers to a thin, low median septum, separating very poorly impressed adductor scars.

DISCUSSION. Harper's (1952) original description of *Kullervo hibernica* was based on limited material. In respect of the external ornament, overall shape and ventral interior the described material is comparable to the paratype material of *Kullervo hibernica* Harper from Grangegeeth (NMING: F14035, 14036). However, a single well-preserved brachial valve interior from Carrigadaggan (Pl. 9, figs 12, 13) shows some differences from the holotype of *hibernica* (NMING: F14034; Pl. 9, fig. 18), which is itself broken and missing posteriorly; in the *hibernica* holotype the impression of external ribs is more regular, stronger and abruptly and evenly terminated. In the Carrigadaggan specimen the ribs are variably impressed, also more irregular and longer. However, an additional broken, poor specimen does show a more regular and even impression of external ribs. In both specimens, a thick, well-developed median ridge, continuous with the notothyrial platform, tapers at about mid-length to a thin, low median septum between the anterior adductors. The most noticeable difference is in the anterior adductor scars. In *K. hibernica* they are very strongly impressed with raised edges, but in the Carrigadaggan specimen they are barely seen and less divergent.

With such a small sample these differences are not deemed to justify erection of a new species. Larger samples are needed to clarify the relationship of the Irish specimens of *Kullervo* to each other and other poorly known species, especially since the material described herein is mostly fragmentary or broken. It is thus difficult to measure the important morphological characters, but the figured specimens show similar proportions to the type material. Other recent descriptions of *Kullervo* species, such as Whittington & Williams (1955) from the Derfel Limestone of Wales, Wright (1964) from the Portrane Limestone of eastern Ireland, and Hiller (1980) from North Wales, have all drawn attention to Öpik's original description of the genus (1934). In this, he defined four groups on the basis of external ornament. All the present material is similar to group 2, in particular *K. lacunata* Öpik, which has strong radial ribs in the middle sector but dominant concentric ornament on the ears. The material is unlike *K. complectens albida* which has a ventral sulcus bounded by stronger ribs. Consequently, although the type material is poorly known, this material is affiliated to *K. hibernica*. It is possible that larger collections of topotype material may show that *K. hibernica* is synonymous with the Kukruse (*N. gracilis*) form from Estonia, *K. lacunata*, or more likely that it is descended from that species, with an increase of radial ribs and stronger reticulation.

Superfamily **TRIPLESIOIDEA** Schuchert, 1913
Family **TRIPLESIIDAE** Schuchert, 1913
Genus ***BICUSPINA*** Havlíček, 1950

Bicuspina ?sp Pl. 9, fig. 11

MATERIAL AND LOCALITY. Kilbride: 2 internal moulds of brachial valves, and one external mould fragment.

DISCUSSION. These two incomplete dorsal moulds could possibly be assigned to *Bicuspina*, or to the similar genus *Oxoplecia* which Carlisle (1979: 552) recorded from Kilbride. However, the overall shape, especially the very angular dorsal fold, suggests *Bicuspina* is more appropriate.

Superfamily **PLECTAMBONITOIDEA** Jones, 1928
Family **BIMURIDAE** Cooper, 1956
Genus ***BIMURIA*** Ulrich & Cooper, 1942

Bimuria cf. ***dyfiensis*** Lockley, 1980
Pl. 9, figs 14–17; Pl. 12, figs 1–9

?1977 *Bimuria* sp.; Mitchell: 95; pl. 19, figs 24–28.

PLATE 9

Figs 1–10, 12–13 *Kullervo* aff. *hibernica* Harper. Carrigadaggan. **1**, BC 12717, incomplete internal and external mould of pedicle valve, × 4. **2**, BC 12718a, internal mould of pedicle valve, × 2. **3, 7**, BC 12719, external mould of pedicle valve, and latex cast, × 2. **4, 5**, BC 12720, internal mould of pedicle valve, and latex cast, × 4. **6**, BC 12721, latex cast of external mould of pedicle(?) valve, × 4. **8**, BC 12718b, latex cast of external mould of pedicle valve, counterpart of Fig. 2, × 4. **9, 10**, BC 12722, external mould of brachial valve, latex cast and mould, × 4. **12, 13**, BC 12723, internal mould of brachial valve, latex cast and mould, × 4.

Fig. 11 *Bicuspina*? sp. Kilbride. BC 12724, internal mould of brachial valve, × 2.

Figs 14–17 *Bimuria* cf. *dyfiensis* Lockley. Ballykale. **14**, BC 12725, internal mould of pedicle valve, × 32. **15**, BC 12726, dorsal view of internal mould of pedicle valve showing strongly incurved umbo, × 32. **16**, BC 12727a, dorsal view of conjoined internal mould, × 32. **17**, BC 12728, internal mould of pedicle valve, × 32.

Fig. 18 NMING:F14034. Holotype of *Kullervo hibernica* Harper; an internal mould of a brachial valve from Grangegeeth, Co. Meath. × 4.

cf. 1980 *Bimuria dyfiensis* Lockley: 215, figs 60–62, 64–65.

MATERIAL AND LOCALITY. Ballykale: 16 internal moulds of pedicle valves, 3 internal moulds of brachial valves and 4 external moulds of pedicle valves.

DESCRIPTION. *Exterior.* Concavo-convex valves with pedicle valve umbo incurved and overlapping dorsal interarea. Rectimarginate, with subcircular outline. Both valves essentially smooth, with comae absent or very indistinct, resembling growth lines, in the brachial valve. Mean length about three-quarters of width.

Ventral interior. Simple teeth developed laterally for about one-third of the width of the valve but short anteromedially. A pinnate mantle canal pattern surrounding an undifferentiated muscle field is variably impressed (or preserved).

Dorsal interior. Low socket ridges nearly parallel to the hinge line. Prominent submedian septa and a thin median septum within a papillose bema.

MEASUREMENTS
Pedicle valve internal moulds:

Variates	X1	X2
Means	9·89	13·3
Sample size	16	16
Variance-covariance Matrix	12·21	11·36 15·55

DISCUSSION. Specimens are too deformed for reliable quantitative study. The measurements taken are given above, but caution is advised in using them other than as a general guide to the species morphology, because of tectonic deformation. The Ballykale population of *Bimuria* is quite strongly deformed and flattened, so precise comparison with known Scoto-Irish species (*B.* cf. *buttsi* Cooper, *B. youngiana* Davidson, *B. youngiana recta* Williams) is not possible. Enough well-preserved specimens are described to justify assignment to *B.* cf. *dyfiensis*; the most significant feature of the species is the absence of comae. The size of the Ballykale sample is similar to the Welsh sample described by Lockley (1980) from the Gelli-grîn Formation of the Bala area of Wales. The lack of a fold and sulcus is distinctive in this population. *Bimuria* sp. from Kilbride (below) is of a much smaller mean size but otherwise shows very little difference from *B.* cf. *dyfiensis*. It is described under open nomenclature in the absence of dorsal interiors and exteriors, and because it is also similar in internal morphology and size to *B. youngiana recta* Williams. One poor pedicle valve exterior, however, shows no evidence of comae. The lack of comae is a feature of *Bimuria* sp. from the Ashgill Killey Bridge Formation at Pomeroy (Mitchell 1977), although that form is gently sulcate. The size of specimens in this small sample is intermediate between *B.* cf. *dyfiensis* and *Bimuria* sp. from Kilbride. It seems likely that all three samples are closely related, but further specimens, preferably undeformed, are needed to verify this.

Bimuria sp. Pl. 10, figs 1–7

MATERIAL AND LOCALITY. Kilbride: 21 internal moulds and one external mould of pedicle valves.

DESCRIPTION. *Exterior.* Unknown, except for one smooth, but poorly preserved valve.

Ventral interior. Strongly concavo-convex valve with strongly incurved umbo of pedicle valve overlapping dorsal interarea. Rectimarginate anterior commissure. Shell outline variable, from occasionally subcircular to sometimes transverse. Maximum width just anterior of hinge line, at about 27% of length. Length is always less than width; mean value is 78%. Depth of ventral valve is nearly half the length (44%).

Dorsal interior. Unknown.

MEASUREMENTS
Pedicle valve internal moulds (Kilbride):

Variates	X1	X2	X3	X4
Means	6·12	7·90	1·57	2·71
Sample size	19	20	20	20
Variance-covariance Matrix	2·62	2·51 3·23	0·89 0·65 0·69	1·16 1·01 0·44 0·81

DISCUSSION. See *Bimuria* cf. *dyfiensis*, above.

Family **LEPTELLINIDAE** Ulrich & Cooper, 1936
Subfamily **LEPTELLININAE** Ulrich & Cooper, 1936
Genus and subgenus ***LEPTELLINA (LEPTELLINA)*** Ulrich & Cooper, 1936

Leptellina* (*Leptellina*)** cf. ***llandeiloensis (Davidson, 1883) Pl. 10, figs 8–14

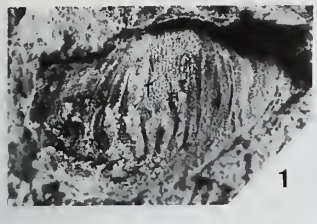
cf. 1883 *Leptaena llandeiloensis* Davidson: 171; pl. 12, fig. 26, *non* figs 27–29.
cf. 1917 *Plectambonites Llandeiloensis* (Davidson); Reed: 876; pl. 13, figs 32–34; pl. 14, figs 1–3.
cf. 1928 *Leptelloidea llandeiloensis* (Davidson); Jones: 477.
cf. 1962 *Leptellina llandeiloensis* (Davidson); Williams: 164; pl. 15, figs 27–29, 32.

PLATE 10

Figs 1–7 *Bimuria* sp. Kilbride. **1**, BC 12729, internal mould of pedicle valve, × 4. **2**, BC 12730, internal mould of pedicle valve, × 4. **3**, BC 12731, internal mould of pedicle valve, × 4. **4**, BC 12732, internal mould of pedicle valve, × 4. **5**, BC 12733, internal mould of pedicle valve, × 4. **6**, BC 12734a, internal mould of pedicle valve, × 4. **7**, BC 12734b, external mould of pedicle valve, counterpart of Fig. 6, × 4.

Figs 8–14 *Leptellina (Leptellina)* cf. *llandeiloensis* (Davidson). Carrigadaggan. **8, 9**, BC 12735, internal mould of pedicle valve, and latex cast, × 4. **10**, BC 12736, internal mould of pedicle valve, × 2. **11, 13, 14**, BC 12737, internal mould of pedicle valve, posterior view, latex cast, and dorsal view, × 2. **12**, BC 12738, latex cast of internal mould of brachial valve, × 4.

Figs 15–21 *Leptestiina oepiki* Whittington. **Figs 15–18**, Kildare, Grange Hill Horizon 1. **15**, BC 12739, internal mould of pedicle valve, × 4. **16, 17, 18**, BC 12740, internal mould of brachial valve, posterior and dorsal views of latex cast, and mould, × 4. **Figs 19–21**, Kilbride. **19**, BC 12741, internal mould of brachial valve, × 4. **20, 21**, BC 12742, internal mould of brachial valve, latex cast and mould, × 4.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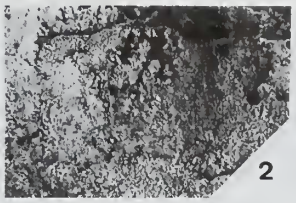
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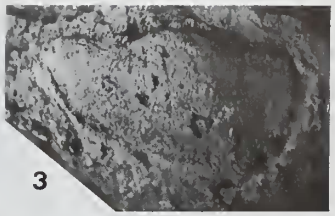
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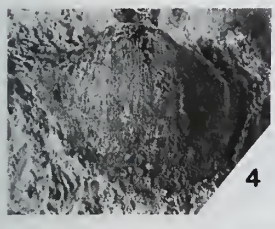
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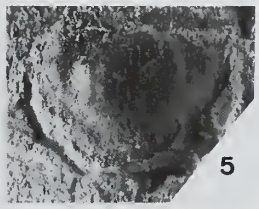
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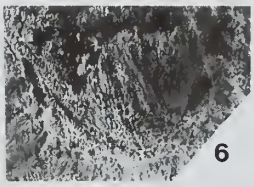
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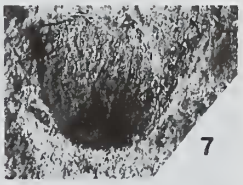
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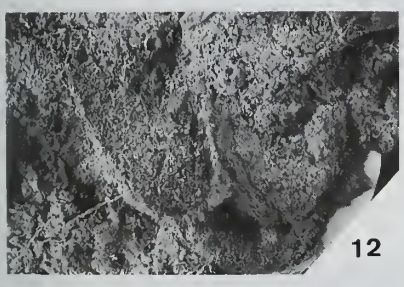
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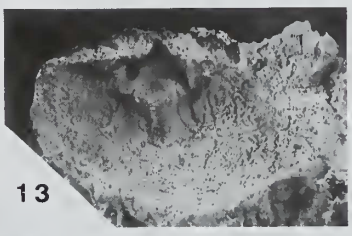
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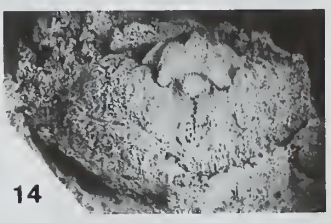
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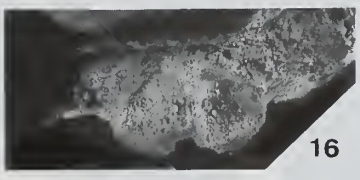
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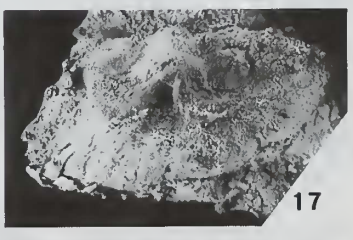
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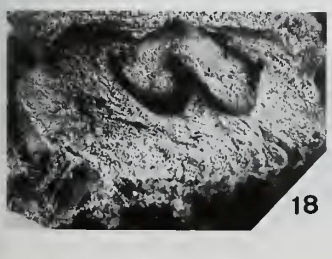
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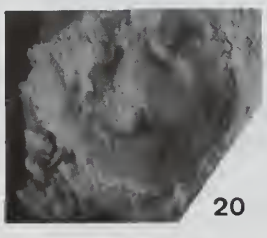
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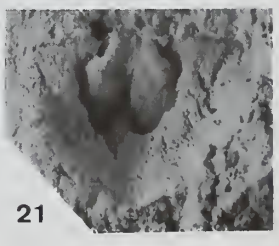
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cf. 1977 *Leptellina* cf. *llandeiloensis* (Davidson); Mitchell: 72; pl. 13, figs 14–17.
cf. 1978 *Leptellina llandeiloensis* (Davidson); Cocks: 93.

MATERIAL AND LOCALITY. Carrigadaggan. 3 internal moulds of pedicle valves, and 3 incomplete internal moulds of brachial valves.

DESCRIPTION. *Exterior*. Unknown.

Ventral interior. Convex, transverse, nearly semicircular about 70% as long as wide and 40% as deep as long, rectimarginate anterior commissure. Maximum depth at about mid-length. Orthocline interarea about 20% of valve length. Deeply impressed large, quadrilobate muscle field 80% as long as wide, and extending anteriorly to about mid-length of valve. Small diamond-shaped platform anterior of and between the muscle field lobes, depressed in centre and with 4, 6 and 8 coarse pustules in a row on the anterior slope of the platform, sagittally. Delthyrium apparently open. Saccate pattern of mantle canals.

Dorsal interior. Large, well-defined platform is strongly elevated, ankylosed with a median septum and medially indented.

DISCUSSION. The present material is clearly inadequate for an unequivocal identification, in the absence of complete brachial valve interiors or any exteriors, but is assigned to *L.* cf. *llandeiloensis* because of the strong similarities to the material described by Mitchell (1977: 72) from the Caradoc Bardahessiagh Formation of Pomeroy. Previous descriptions have not recorded or remarked on the presence of a discrete median row of pustules anteriorly of the diamond shaped platform, but Mitchell's (1977: pl. 13, figs 14, 16) figured specimens clearly show them. What significance should be attached to this is unknown, since although Williams' (1962: pl. 15, fig. 28) specimens show them, he also figures a specimen of *Leptellina semilunata* (1962: pl. 15, fig. 23) which has a less ordered but equally strong row.

Family **LEPTESTIIDAE** Öpik, 1933, *emend*. Cocks & Rong, 1989

Genus ***LEPTESTIINA*** Havlíček, 1952

REMARKS. Cocks & Rong (1989: 116) reduced *Leptestiina* to a subgenus of *Leangella* Öpik, 1933. This is not followed here since, although Melou (1971) showed a phylogenetic sequence from *Leptestiina derfelensis* through *L. prantli* and *L. aonensis* to *Tufoleptina* (=*Leangella*), the early members of the lineage such as *Leptestiina oepiki, L. derfelensis* and *L. indentata* are sufficiently distinctive from *Leangella*, in the lack of a platform (*sensu* Cocks & Rong, 1989) anteriorly.

Leptestiina oepiki Whittington, 1938

Pl. 10, figs 15–21; Pl. 11, figs 1–6

1938 *Sampo oepiki* Whittington:255; pl. 10, figs 15–16; pl. 11, fig. 10.
1963 *Leptestiina oepiki* (Whittington); Williams: 428–430; pl.10, figs 15, 16, 19–21.
1978 *Leptestiina oepiki* (Whittington); Cocks: 94.
1989 *Leangella* (*Leptestiina*) *oepiki* (Whittington); Cocks & Rong: 116–117.

MATERIAL AND LOCALITIES. Kilbride: 6 internal and 1 external moulds of brachial valves; 4 internal and 1 external mould of pedicle valves. Kildare, Grange Hill, Horizon 1: 4 internal moulds of a pedicle valve and 2 internal moulds of brachial valves. Greenville-Moyne: 3 internal moulds of pedicle valves and 2 internal moulds of brachial valves.

DESCRIPTION. *Exterior*. Evenly concavo-convex valves, of semicircular outline. Pedicle valve about 60% as long as wide, and about 35% as deep as long. Ornamentation poorly-known, unequally parvicostellate with very fine costellae separated by few thicker ribs. Ventral interarea apsacline, dorsal interarea hypercline.

Ventral interior. Short blunt teeth supported by short receding dental plates, bordering a transversely subpentagonal muscle field which extends about 23% of valve length anteriorly. Length of muscle field about 50% of width. Deeply impressed vascula markings with lemniscate pallial sinus pattern.

Dorsal interior. Characteristically longitudinally and radially striated bema, bilobed and undercut with median incision and septum separating the two rounded lobes which originate laterally from the socket ridges, bounding oval sockets. Bema is about two-thirds as long as wide and extends anteriorly half the length of the valve.

DISCUSSION. The species *L. oepiki* is known from the Longvillian of Wales (Williams 1963: 428) and possibly the Actonian of Shropshire (Hurst 1979*a*: 275). Williams (1963: 430) noted the similarities between *L. oepiki* and the closely related Costonian species *L. derfelensis* Jones, 1928, from the Derfel Limestone in North Wales. He suggested the two may be synonymous, but the resolution of this must await further collections of *Leptestiina derfelensis* as well as more Irish material. The present sample is too small and poorly preserved to assess the variability of the species, particularly the external ornament. *L.* aff. *oepiki* is also known from Pomeroy, Co. Tyrone, in the Cautleyan Killey Bridge Formation (Mitchell 1977: 76); this also resembles *L. derfelensis* in some respects.

Harper (*in* Harper & Owen 1984: 29) revised the Upper Caradoc Norwegian species *L. indentata* (Spjeldnaes 1957:

PLATE 11

Figs 1–6 *Leptestiina oepiki* Whittington. Kilbride. **1**, BC 12743, internal mould of pedicle valve, × 4. **2, 3**, BC 12744, internal mould of brachial valve, and latex cast, × 4. **4**, BC 12745, internal mould of pedicle valve, × 4. **5**, BC 12746, internal mould of brachial valve, × 4. **6**, BC 12747, internal mould of brachial valve, × 4.

Figs 7–15, 17 *Leptestiina oepiki ampla* subsp. nov. Carrigadaggan. **7, 8**, **Holotype** BC 12748, internal mould of brachial valve, and latex cast, × 4. **9, 10**, BC 12749, internal mould of brachial valve, and latex cast, × 4. **11**, BC 12750, external mould of brachial valve, × 4. **12**, BC 12751, internal mould of pedicle valve, × 4. **13**, BC 12752, internal mould of pedicle valve, × 4. **14**, BC 12753, internal mould of pedicle valve, × 4. **15**, BC 12754, external mould of brachial valve, × 4. **17**, BC 12755, external mould of pedicle valve, × 4.

Fig. 16 *Reuschella*? sp. Kilbride. BC 12756, internal mould of pedicle valve, × 2.

Figs 18–20 *Salopia* sp. **Fig. 18**, Greenville-Moyne.BC 12757, internal mould of brachial valve, × 2. **19, 20**, Kildare, Grange Hill Horizon 2. BC 12758, internal mould of pedicle valve, and latex cast, × 2.

Figs 21–22 *Porambonites* sp. Kilbride. **21**, BC 12759, internal mould of pedicle valve, × 2. **22**, BC 12760, internalmould of pedicle valve, × 2.


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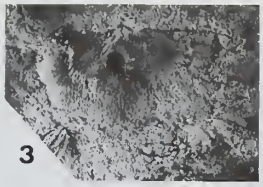
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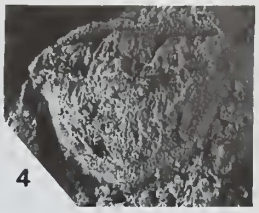
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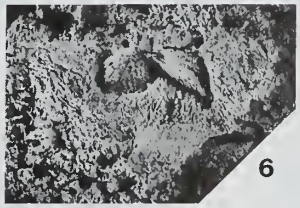
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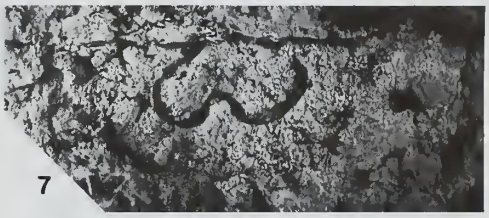
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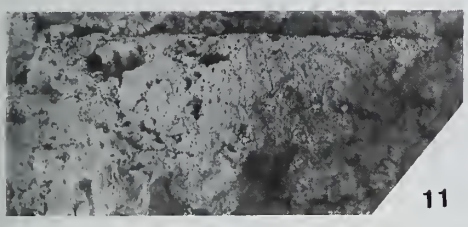
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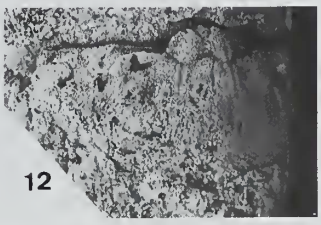
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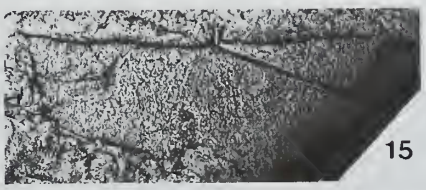
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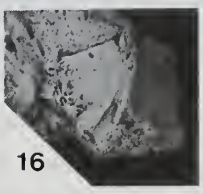
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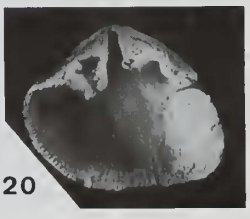
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69). Although closely similar, this form has an apparently smooth bema and a greater frequency of accentuated ribs (at least 7) than *L. oepiki*. They synonymized a population from the Actonian of Shropshire which Hurst (1979*a*) had assigned to *L. oepiki*, based only on internal moulds. The one figured specimen of *L.* sp. (Hurst 1979*a*: 75, fig. 408), also from Shropshire and synonymized by Harper & Owen (1984), clearly shows a striated bema. Clearly, better preserved material of all these forms would be desirable, especially exteriors.

The inclusion of *L. indentata* in *Bilobia* by Cocks & Rong (1989: 114) is considered erroneous, since the species does not have the platform (*sensu* Cocks & Rong) near the anterior margin, a feature obviously present in *Bilobia* (Cocks & Rong 1989: 115, figs 70–71) but absent in *Leptestiina*. The bema is also more typically rounded and transverse, as in *Leptestiina* species, than the more complex divided bema of *Bilobia*.

Leptestiina oepiki ampla subsp. nov. Pl. 11, figs 7–17

NAME. Latin; 'wide'.

DIAGNOSIS. Typical *Leptestiina oepiki* in all respects except for the significantly more transverse bema than in the nominate subspecies.

HOLOTYPE. BC 12748 (Pl. 11, figs 7, 8); paratypes BC 12749–55; Carrigadaggan.

MATERIAL AND LOCALITY. Carrigadaggan: 19 internal and 1 external moulds of pedicle valves; 2 internal and 2 external moulds of brachial valves.

DISCUSSION. The new subspecies accords with the material from Kilbride and Kildare, Grange Hill in all respects except for one feature. The bema is more transverse, the mean length being 46% of the width in two valves, as opposed to a mean of 70% for 6 valves from Kilbride and 63% for 2 valves from Grange Hill. It is difficult to assess theimportance of this difference on such a small sample, but until the collection of more topotype material proves otherwise the Carrigadaggan population is assigned to the new subspecies *L. oepiki ampla*.

Family **XENAMBONITIDAE** Jones, 1928
Subfamily **AEGIROMENINAE** Havlícek, 1961
Genus ***CHONETOIDEA*** Jones, 1928

Chonetoidea abdita (Williams, *in* Whittington & Williams 1955) Pl. 12, figs 10–16

1955 *Sericoidea abdita* Williams, *in* Whittington & Williams: 418; pl. 39, figs 83–85.

MATERIAL AND LOCALITY. Greenville: 21 external and 14 internal moulds of pedicle valves, 32 external and 12 internal moulds of brachial valves.

DESCRIPTION. *Exterior*. Concavo- or planoconvex, small shells of transversely semicircular outline, maximum width at hinge line. Cardinal angles acute to rectangular. Ventral valve most convex near umbo in lateral profile, about 15% as deep as long. Anterior profile rectimarginate, evenly convex, occasionally strongly convex medially. Length is 58% of the width (N = 53). Dorsal interarea hypercline and short, ventral interarea apsacline. Ornament quite variable, commonly finely costellate, occasionally parvicostellate, with about 10 ribs per mm, 2 mm anterior of the umbo.

Ventral interior. Very weakly impressed bilobed small muscle field. Small, simple teeth project dorsilaterally and are unsupported. Anterior margins of shell show feebly developed ribs, sometimes extending posteriorly to mid-valve. Interspaces and valve interior characterized by minute pustules.

Dorsal interior. Short socket ridges ankylosed to small cardinal process. Thin median septum extends to mid-length of valve. Variable septule development, commonly 4, 5 or 6 septules arranged in an arc from the anterior end of the median septum. Occasionally second anterior arc of septules or very large circular pustules, third arc of coarse pustules rarely developed. External ornament impressed on finely pustulose interior.

Chonetoidea cf. ***abdita*** (Williams, *in* Whittington & Williams 1955) Pl. 13, figs 1–4

MATERIAL AND LOCALITY. Kilbride: 6 internal and 2 external moulds of brachial valves, 14 internal and 7 external moulds of pedicle valves.

DESCRIPTION. *Exterior*. Small semicircular *Chonetoidea*, widest at the hinge line. Concavoconvex profile, with maximum convexity at umbo, about 20% as deep as long. Rectimarginate, with evenly convex anterior profile. Length about 64% of width. Hypercline, short dorsal interarea, apsacline ventral interarea. Variable ornament, parvicostellate to finely costellate, with occasional thickened ribs, with 15, 13 and 12 ribs per mm 2 mm anteriorly on 2, 1 and 1 valves.

Ventral interior. Small, weakly impressed muscle field. Unsupported, short simple teeth. Interior shows relatively strongly impressed ornament, particularly the accentuated ribs of parvicostellate specimens.

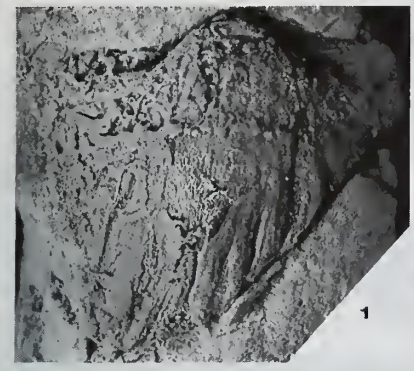
Dorsal interior. Thin median septum extends over half the valve length. Variable septule development in one or two arcs, commonly 4 to 7 septules in the posterior arc from the anterior end of the median septum. External ornament is impressed on interior, particularly the accentuated ribs of parvicostellate specimens.

DISCUSSION. The placing of *Sericoidea* in synonomy with

PLATE 12

Figs 1–9 *Bimuria* cf. *dyfiensis* Lockley. Ballykale. **1**, BC 12761, internal mould of pedicle valve, × 4. **2, 3**, BC 12762, internal mould of pedicle valve, and latex cast, × 48. **4, 5**, BC 12763, internal mould of brachial valve, and latex cast, × 48. **6**, BC 12764, dorsal view of conjoined internal mould, × 48. **7, 8**, BC 12765, external mould of brachial valve and part of pedicle valve, and latex cast showing interareas, × 48. **9**, BC 12766, external mould of brachial valve, × 48.

Figs 10–16 *Chonetoidea abdita* (Williams). Greenville. **10**, BC 12767, internal mould of brachial valve, × 10. **11**, BC 12768b, external mould of pedicle valve, × 10. **12**, BC 12769a, internal mould of brachial valve, × 4. **13**, BC 12770b, external mould of brachial valve, × 4. **14**, BC 12771, external mould of brachial valve, × 10. **15**, BC 12772a, internal moulds of adjoined pedicle and brachial valves, × 4. **16**, BC 12768a, internal mould of pedicle valve, counterpart of Fig. 11, × 10.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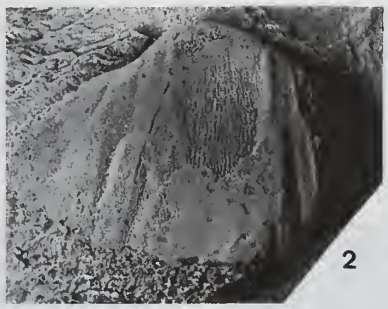
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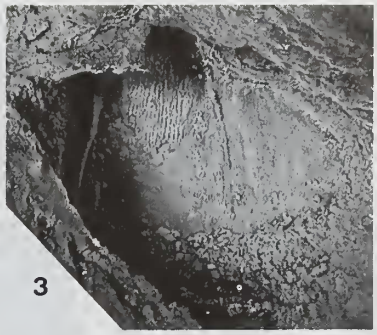
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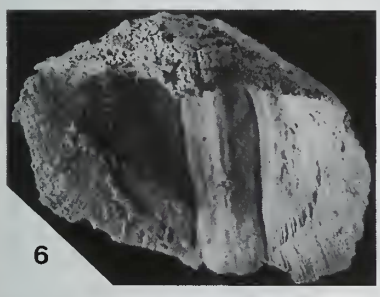
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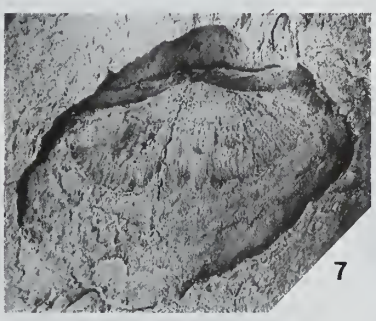
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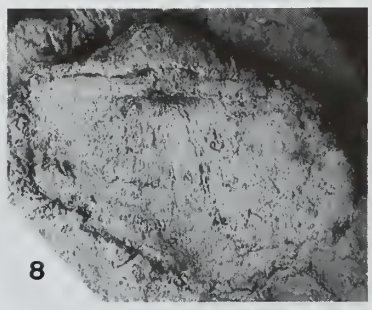
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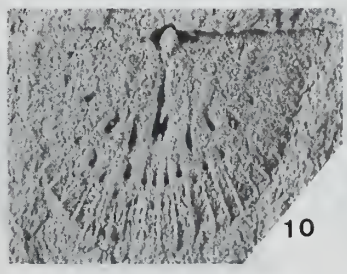
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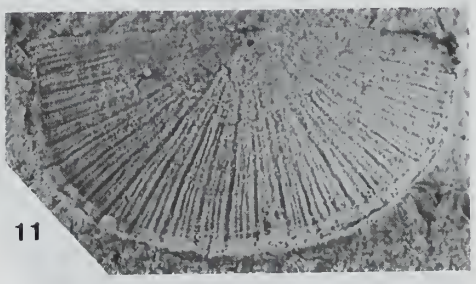
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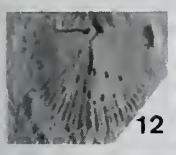
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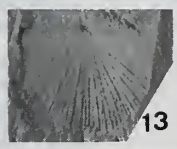
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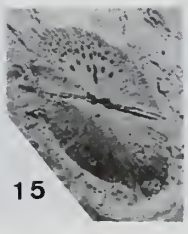
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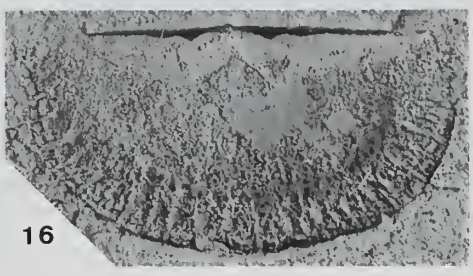
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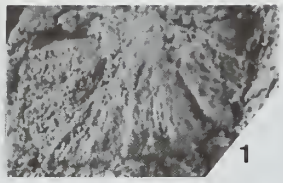
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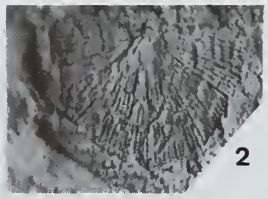
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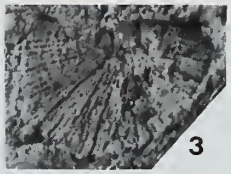
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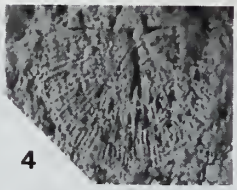
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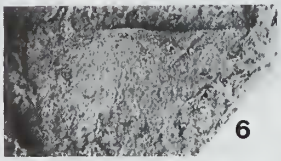
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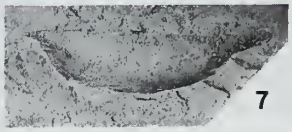
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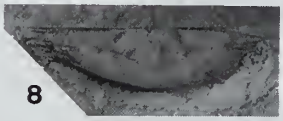
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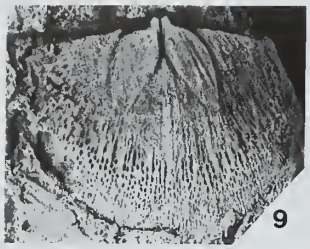
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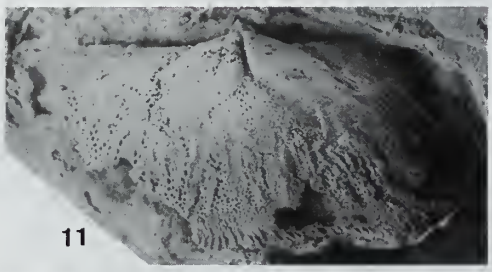
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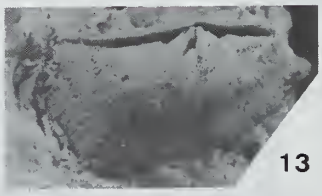
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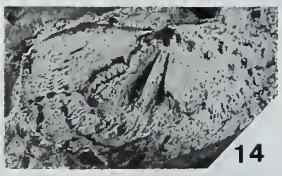
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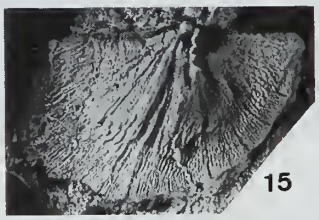
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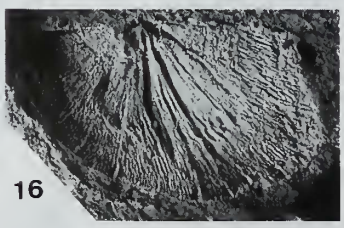
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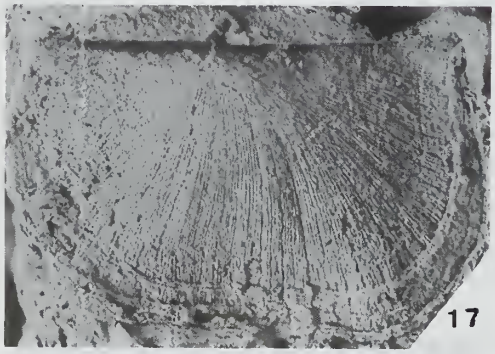
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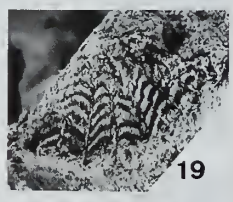
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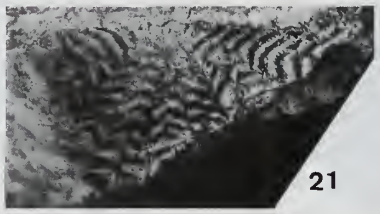
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22

MEASUREMENTS
Brachial valve internal moulds (Greenville):

Variates	X1	X2	X24
Means	2·94	5·21	1·49
Sample size	12	12	9
Variance-covariance	0·50	0·0	0·24
Matrix		0·73	0·05
			0·16

Brachial valve external moulds (Greenville):

Variates	X1	X2
Means	2·87	5·17
Sample size	32	32
Variance-covariance	0·34	0·20
Matrix		1·22

Pedicle valve internal moulds (Greenville):

Variates	X1	X2	X4
Means	3·08	5·41	0·48
Sample size	14	14	9
Variance-covariance	0·28	0·05	–0·02
Matrix		1·15	–0·01
			0·01

Pedicle valve external moulds (Greenville):

Variates	X1	X2	X4
Means	2·99	5·29	0·52
Sample size	21	21	6
Variance-covariance	0·27	0·14	0·03
Matrix		1·06	0·03
			0·01

MEASUREMENTS
Brachial valve internal moulds (Kilbride):

Variates	X1	X2	X24
Means	2·00	3·25	1·05
Sample size	6	6	2
Variance-covariance	0·12	0·17	
Matrix		0·63	

Pedicle valve internal moulds (Kilbride):

Variates	X1	X2	X4
Means	2·19	3·39	0·44
Sample size	14	14	14
Variance-covariance	0·08	0·03	0·02
Matrix		0·29	0·01
			0·02

Pedicle valve external moulds (Kilbride):

Variates	X1	X2	X4
Means	2·17	3·49	0·54
Sample size	7	7	7
Variance-covariance	0·12	0·18	0·02
Matrix		0·55	0·05
			0·01

Chonetoidea by Cocks & Rong (1989) completes a task suggested by many authors, including Hurst (1979*a*: 281) and Young & Gibbons (1983), but not completed for lack of sufficient material. The two described species are a clear vindication of that decision, possessing characters variable between those previously characteristic of both genera. These include the external ornament (parvicostellate (*Sericoidea*) to finely costellate (*Chonetoidea*)) and septule arrangement (few septules in one arc (*Sericoidea*) to many septules and more than one arc (*Chonetoidea*)). The interarea preservation is not good enough to discern whether canals are present, as defined by Mitchell (1977: 93) in *Chonetoidea*.

Although the generic assignment is clearly to *Chonetoidea*, the assignment of the two samples to *Chonetoidea abdita* and *Chonetoidea* cf. *abdita* is made with some hesitation. Other workers have found it difficult to distinguish species effectively on the basis of shape or outline. The only commonly variable characters found to be useful are the frequency of costellae and the arrangement and number of septules or sub-median septae in the lophophore platform of the brachial valve. Comparisons with described species are hindered by differences in numerical description. For example, older descriptions note the number of costellae per mm at the anterior margin irrespective of size, whilst later workers and my own counts were per mm at 2mm sagittally. Some recent work has reverted to marginal counts, e.g. Harper (1989). In

PLATE 13

Figs 1–4 *Chonetoidea* cf. *abdita* (Williams). Kilbride. **1**, BC 12773, internal mould of pedicle valve, × 10. **2**, BC 12774b, external mould of brachial valve, × 10. **3**, BC 12808, external mould of pedicle valve, × 10. **4**, BC 12774a, internal mould of brachial valve, counterpart of Fig. 2, × 10.

Figs 5–8 *Anisopleurella* cf. *multiseptata* (Williams). Greenville-Moyne. **5**, BC 12776a, internal mould of brachial valve, × 4. **6**, BC 12776b, external mould of brachial valve, counterpart of Fig. 5, × 4. **7**, BC 12777b, external mould of pedicle valve, × 2. **8**, BC 12777a, internal mould of pedicle valve, counterpart of Fig. 7, × 2.

Figs 9–18 *Sowerbyella sericea* (J. de C. Sowerby). **Figs 9–14,17**, Kildare, Grange Hill Horizon 1. **9**, BC 12778, internal mould of pedicle valve, × 4. **10**, BC 12779, internal mould of pedicle valve, × 4. **11**, BC 12780, internal mould of pedicle valve, × 4. **12**, BC 12781, internal mould of pedicle valve, × 4. **13**, BC 12782, internal mould of pedicle valve, × 4. **14**, BC 12783, internal mould of brachial valve, × 4. **17**, BC 12785, external mould of brachial valve and interareas, × 4. **Figs 15, 16, 18**, Kilbride. **15, 16**, BC 12784, internal mould of brachial valve, latex cast and mould, × 4. **18**, BC 12786, external mould of brachial valve, × 4.

Figs 19–22 *Ptychoglyptus* sp. Kilbride. All incomplete external (?) moulds. **19**, BC 12787, × 4. **20**, BC 12788, × 4. **21**, BC 12789, × 5. **22**, BC 12790, × 4.

addition, the precision of the counts is slightly suspect, given the very small size of specimens.

Notwithstanding the problem of definition of septules *versus* coarse pustules (see Lockley, 1980: 215), the development of second arcs and more septules is not dependent on size, since smaller specimens can have as many or more than medium or large specimens in the two samples. Although Lockley (1980: 214, fig. 63) gives a useful table of the number of septules in different size classes, it is not clear whether this is total numbers or of one particular arc where more than one is developed. In the Greenville sample, 4 out of 12 measured brachial valves have second arcs developed with 2, 9, 12 and 13 septules present, and the third one has a third arc developed with 11. In isolation, these would probably be identified as *Chonetoidea papillosa* or *Chonetoidea radiatula*. In the Kilbride species, 2 out of 6 had a second arc with 6 and 12 septules.

Neither species is like the type species *Chonetoidea restricta* (Hadding) or *Chonetoidea homolensis* Havlíček (see Harper, 1989) as the median septum and septule arcs in these species are contained within the posterior half of the shell. Although contemporaneous, *Chonetoidea* sp. from the Gelli-grîn Formation (Williams 1963) differs in having a platform developed by coalescence of strong septules. Percival (1979: 115) described two species, *Chonetoidea sejuncta* and *Chonetoidea minor*, which together with *Chonetoidea virginica* (Cooper, 1956) form a distinct species group. These have a thin median septum extending up to mid-length, but the 2 to 4 pairs of discrete small septules are positioned laterally in a row, not arcuate as in the Greenville and Kilbride samples.

In summary, both the Leinster species are best assigned to the *Chonetoidea abdita* Williams form, as emended by Lockley (1980). The original species description was limited owing to paucity of material. Williams has compared Lower Caradoc material from the Balclatchie Group (1962) of Girvan and the Soudleyan Hagley Shales of Shropshire (1974) with the Welsh form, and noted little difference. Although the poorly preserved Kilbride form is here described separately, as it is somewhat deeper and has a slightly greater frequency of costellae than the Greenville sample, these differences are probably not important. All the forms compared to the species, including these samples, are probably displaying a range of variation wider than that normally seen in the often small samples available. The actual data for septule and costellae numbers are given for comparison (Tables 21–22).

Table 21 Frequency of counts of costellae per mm at 2 mm sagitally for *Chonetoidea abdita* from Greenville, *Chonetoidea* cf. *abdita* from Kilbride, *Chonetoidea* cf. *abdita* from Shelva (data from Williams, 1974) and at the anterolateral margins for *Chonetoidea* aff. *abdita* from Girvan (data from Williams, 1962).

8	9	10	11	12	13	14	15	16	Total	
4	8	12	10	3	3	2	3	1	46	*C. abdita* Greenville
				1	1		2		4	*C.* cf. *abdita* Kilbride
			3	3	1				7	*C.* cf. *abdita* Shelve
			3	7	8	6	3	1	28	*C.* aff. *abdita* Girvan

Table 22 Distribution of various types of lophophore platform, with number of septules on either side of median septum (MS) in columns for *Chonetoidea abdita* samples. Data for *Chonetoidea abdita* from Greenville (left columns) and *Chonetoidea* cf. *abdita* from Kilbride (central columns) based on posterior arc of larger septules when more than one developed. Date for *Chonetoidea* aff. *abdita* from Girvan (right columns) modified from Lockley (1980).

Length (mm)	MS	1	2	3	Total
0·6–1·0	0 0 3				0 0 3
1·1–1·5	0 0 1	0 0 1		0 1 0	0 1 2
1·6–2·0		0 0 2	0 2 0	1 0 4	1 2 6
2·1–2·5		0 0 2	2 1 0	1 1 3	3 2 5
2·6–3·0			3 0 0	0 0 4	3 0 4
3·1–3·5			1 0 0	2 0 3	3 0 3
3·6–4·0				2 0 0	2 0 0
	0 0 4	0 0 5	6 3 0	6 2 14	12 5 23

Genus *ANISOPLEURELLA* Cooper, 1956

Anisopleurella cf. *multiseptata* (Williams, *in* Whittington & Williams 1955) Pl. 13, figs 5–8

MATERIAL AND LOCALITY. Greenville-Moyne: 8 internal and 2 external moulds of pedicle valves, 2 internal and 5 external moulds of brachial valves.

DISCUSSION. The sparse material, especially brachial valve interiors, is inadequately preserved and moderately deformed, making a specific determination difficult. Brenchley *et al.* (1977) recorded *Anisopleurella* aff. *multiseptata* Williams from this locality, but although similar to that species, the sample is apparently more transverse. Lockley (1980), however, compared a single pedicle valve from the Gelli-grîn Formation of Bala to the species *A. multiseptata* which appears similar to the material from Greenville-Moyne. The exteriors are poor but show the essentially smooth exterior ornamented by a few widely-spaced primary costae, and Brenchley *et al.* (1977) are followed in comparison of this species to *A. multiseptata* Williams.

Family **SOWERBYELLIDAE** Öpik, 1930
Subfamily **SOWERBYELLINAE** Öpik, 1930
Genus and subgenus ***SOWERBYELLA (SOWERBYELLA)*** Jones, 1928

Sowerbyella sericea (J. de C. Sowerby, 1839) Pl. 13, figs 9–18

1839 *Leptaena sericea* J. de C. Sowerby, *in* Murchison: 636; pl. 19, fig. 1.
1928 *Sowerbyella sericea* (J. de C. Sowerby) Jones: 414; pl. 21, figs 1–4.
1963 *Sowerbyella sericea* (J. de C. Sowerby); Williams: 430–432; pl. 11, figs 1–9.
1970 *Sowerbyella sericea* (J. de C. Sowerby); Bretsky: 85–87; pl. 12, figs 3–6; pl. 13, figs 1–4.
cf.1974 *Sowerbyella sericea* (J. de C. Sowerby); Williams: 134–135; pl. 24, figs 11–14, 16.
1978 *Sowerbyella sericea* (J. de C. Sowerby); Cocks: 98.

1979a *Sowerbyella sericea* (J. de C. Sowerby); Hurst: 278; figs 412–432.

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 1: 3 external and 15 internal moulds of pedicle valves; 7 external and 4 internal moulds of brachial valves. Kildare, Grange Hill, Horizon 2: 2 internal moulds of pedicle valves. Kilbride: 9 external and 17 internal moulds of pedicle valves, 7 external and 2 internal moulds of brachial valves. Carrigadaggan: 1 internal mould of a pedicle valve; 4 external and 2 internal moulds of brachial valves.

DESCRIPTION. *Exterior*. Semicircular outline, cardinal angles acute in smaller specimens, becoming rectangular in older stages. Concavo-convex shells, with median fold occasionally developed in pedicle valve, and concave flanks on pedicle valve. Length about 55–60% of the width, and depth about one third of the length in the pedicle valve. Radial ornamentation unequally parvicostellate, but quite variable, with 6–10 costellae per mm, 5 mm anteromedially of the umbo, segregated into sectors about 1 mm wide if not finely costellate. Occasionally a few pairs of rugae developed in posterolateral areas. Dorsal interarea very short, flat and catacline, ventral interarea curved and apsacline.

Ventral interior. Bilobed, divergent diductor muscle scars about 0·7 as long as wide, extending anteriorly for about one-third of valve length. Adductor scars separated posteriorly by thin median septum extending for 15–20% of valve length before bifurcating. Diductors widely separated anteriorly and split by divergent vascula media bounded by lateral ridges. Lemniscate pallial sinus pattern, with papillose anterior surface. Small teeth with obsolescent dental plates in adults.

Dorsal interior: Undercut cardinal process fused with widely divergent socket ridges. The bases of the socket ridges are continuous with two low ridges that rise in height anteriorly to become prominent sub-median septa extending about two-thirds of valve length. Sub-median septa diverge slightly, so that anterior separation is about one-third of their length. Low, small median septum and thinner, low, radial ridges across bema occasionally developed. Lemniscate pallial sinus pattern, and papillose interior anterior of the bema.

DISCUSSION. Although differing slightly in some proportions, from each other and from the type material, the differences are not significant, given the variability known in stocks of *Sowerbyella* (Cocks & Rong 1989: 139) and do not justify erection of a subspecies. A few of the measured specimens are also slightly distorted so the reliability of the statistics is low, but is presented as a general assessment of the morphology. Material from the Grange Hill, Carrigadaggan and Kilbride populations is all referred to the type species *S. sericea* (J. de C. Sowerby). The type species was revised by Williams (1963), and Hurst (1979*a*) figured a large sample of this species from the Woolstonian of south Shropshire to illustrate the variability within the species. The number of dorsal valves is small, but plots of the first four eigenvectors (Fig. 19) from a principal component analysis of pedicle valves from Kildare, Grange Hill and Kilbride shows no differences between the samples, except for overall size where vector 1 shows some differentiation. The Kilbride population has a smaller mean size.

MEASUREMENTS

Brachial valve external moulds (Kilbride):

Variates	X1	X2	X4
Means	6·83	1·21	1·35
Sample size	7	7	6
Variance-covariance	2·08	4·46	0·27
Matrix		12·51	0·57
			0·26

Pedicle valve internal moulds (Kilbride):

Variates	X1	X2	X4	X9	X10	X24
Means	5·51	9·42	1·83	1·43	2·10	0·77
Sample size	17	17	16	6	6	9
Variance-covariance	4·06	4·79	1·11	1·08	1·74	0·78
Matrix			0·70	0·23	0·43	0·28
				0·23	0·27	0·19
					0·49	0·24
						0·15

Brachial valve internal moulds (Kildare, Horizon 1):

Variates	X1	X2	X3	X22	X23
Means	9·38	1·78	2·85	6·08	1·95
Sample size	4	4	4	4	4
Variance	1·17	6·09	0·37	0·32	0·01

Brachial valve external moulds (Kildare, Horizon 1):

Variates	X1	X2	X4
Means	7·96	1·43	1·38
Sample size	7	7	6
Variance-covariance	13·43	17·64	1·55
Matrix		32·97	3·44
			0·57

Pedicle valve internal moulds (Kildare, Horizon 1):

Variates	X1	X2	X4	X9	X10	X24
Means	9·47	15·2	3·53	4·06	5·76	2·20
Sample size	15	15	15	14	14	14
Variance-covariance	3·61	4·97	0·69	1·88	2·33	0·86
Matrix		16·24	2·79	2·62	5·77	1·54
			1·48	0·52	1·27	0·29
				1·24	1·38	0·51
					2·62	0·77
						0·43

Pedicle valve external moulds (Kildare, Horizon 1):

Variatesa	X1	X2	X4
Means	9·47	16·0	3·27
Sample size	3	3	3
Variance	1·04	2·82	0·22

Subfamily **PTYCHOGLYPTINAE** Cooper, 1956
Genus ***PTYCHOGLYPTUS*** Willard, 1928

Ptychoglyptus sp. Pl. 13, figs 19–22

MATERIAL AND LOCALITY. Kilbride: All material incomplete; one internal and one external moulds of a pedicle valve, one internal and one external moulds of a brachial valve, and 8 indeterminate moulds.

DESCRIPTION. Characteristic *Ptychoglyptus* rugae with a wavelength of 2 per mm, separated into discontinuous arcuate chevron-like pattern by strong radial costellae. Whole of surface, including rugae, sculpted with fine radial lines. Straight hinge line and slight rafinesquinoid convexity in pedicle valve. The dorsal interior is inadequately known.

MEASUREMENT. One specimen shows most of half a hinge line and gives a minimum hinge width of 21 mm.

DISCUSSION. The material is too fragmentary to justify a specific determination. It appears to be unlike *P.* ? *kindlei* Cooper (1956) which has a geniculate anterior, and also unlike *P.* ? *matura* Cooper (1956) which is non-rugose in the anterior half. It is comparable to *P. virginiensis* Willard (1928) in most respects except for the rugose sculpture. As Williams (1962) noted, this species has rounded crests to the rugae and is generally symmetrical or asymmetrical with steeper posterior slopes. Williams (1962) described three specimens of *P.* cf. *valdari* from Balclatchie, near Girvan in Scotland, with sharply asymmetrical rugae, and three with rugae overfolded in an anterior direction. The material from Kilbride most closely resembles this species since the crests are sharp and asymmetrical. The posterior slope is steeper but in some rugae there is an anteriorly deflected crest, creating an overfolded appearance, but it is variably developed within single specimens.

Superfamily **STROPHOMENOIDEA** King, 1846
Family **STROPHOMENIDAE** King, 1846
Subfamily **STROPHOMENINAE** King, 1846
Genus ***STROPHOMENA*** Rafinesque, 1825

Strophomena ? sp Pl. 14, figs 13, 6

MATERIAL AND LOCALITY. Kildare, Grange Hill, Horizon 1: 2 external and 1 internal moulds of a pedicle valve.

DESCRIPTION. Gently, evenly convex pedicle valve with very shallow sulcus. Interarea high, apsacline about 14% as long as the valve. Simple triangular teeth supported by short divergent dental plates. Delthyrium almost completely closed by convex pseudodeltidium. Faint transverse grooves and ridges on the interarea near the hinge line. Interior shows impression of ornament throughout, especially at margins. External ornament finely costellate with about 6 ribs per mm at 5 mm growth stage. Strong concentric, accentuated growth lines on exterior of shell.

MEASUREMENTS. BC 12791a & b: X1 = 28 mm, X2 = 21 mm, X4 = 3 mm, X6 = 38 mm; X1/X2 = 0·75, X4/X1 = 0·11, X6/X1 = 0·14 (Pl. 14, figs 1–3, 6).

DISCUSSION. Although the unequally parvicostellate ornament is lacking, the single valve part and counterpart moulds are questionably assigned to *Strophomena*, as the general morphology corresponds to the genus in other aspects. However it is 75% as wide as long, unlike species from Wales that are wider than long; there is no apparent deformation of the specimen.

Genus ***KJERULFINA*** Bancroft, 1929

Kjerulfina ? sp. Pl. 14, fig. 7

MATERIAL AND LOCALITY. Kildare, Grange Hill, Horizon 1: a single internal mould of pedicle valve, incomplete.

MEASUREMENTS. BC 12792: X1 = 15 mm, X4 = 33 mm (Pl. 14, fig. 7).

DISCUSSION. This incomplete mould has an initially gently convex profile, but deflects abruptly in a ventral direction before geniculating sharply in a dorsal direction. It is moderately wrinkled by rugae posterolaterally and is finely ornamented by costellae impressions. The dental plates are divergent, short and curving. The specimen exhibits similarities to *Kjerulfina*, one species of which, *K. broeggeri*, has similar sporadic dorsally directed geniculation. Further material is required to reach a better identification.

Subfamily **RAFINESQUININAE** Schuchert 1893
Genus ***RAFINESQUINA*** Hall & Clarke 1892

Rafinesquina sp. Pl. 14, figs 4–5, 8–10, 14–17

MATERIAL AND LOCALITY. Kildare, Grange Hill House Cottage: 5 internal and 5 external moulds of pedicle valves, 8 internal and 4 external moulds of brachial valves, 4 indeterminate external moulds and 3 indeterminate internal moulds, mostly fragmentary.

DISCUSSION. The best specimens of this genus are figured to show the typical form of the sample, but it is not described pending collection of more material to assess the morphological variation. It shows typical concavo-convex form, and unequally parvicostellate ornamentation. However, there are few modern descriptions of the genus from Britain or Ireland

PLATE 14

Figs 1–3, 6 *Strophomena*? sp. Single specimen from Kildare, Grange Hill Horizon 1. **1, 2**, BC 12791b, external mould of pedicle valve, and latex cast, × 2. **3, 6**, BC 12791a, counterpart internal mould of pedicle valve, and latex cast, × 2.

Fig. 7 *Kjerulfina*? sp. Kildare, Grange Hill Horizon 1. BC 12792, internal mould of pedicle valve, × 2.

Figs 4–5, 8–10, 14–17 *Rafinesquina* sp. Kildare, Grange Hill House Cottage. **4, 5**, BC 12793, internal mould of brachial valve, latex cast and mould, × 2. **8**, BC 12794, internal mould of pedicle valve, × 175. **9**, BC 12795b, external mould of pedicle valve, × 2. **10, 14**, BC 12795a, internal mould of pedicle valve, counterpart of Fig. 9, latex cast and mould, × 2. **15**, BC 12796b, external mould of brachial valve, × 2. **16, 17**, BC 12796a, internal mould of brachial valve, counterpart of Fig. 15, latex cast and mould, × 2.

Figs 11–13 *Hedstroemina* sp. Kildare, Grange Hill Horizon 1. **11**, BC 12797a, internal mould of pedicle valve, × 2. **12**, BC 12798, internal mould of pedicle valve, × 2. **13**, BC 12799, internal mould of pedicle valve, × 2.


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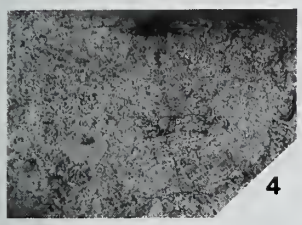
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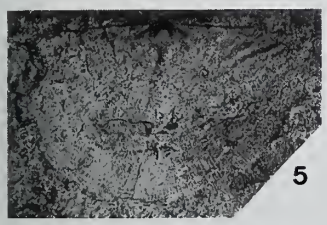
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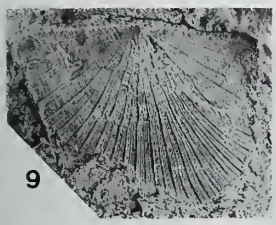
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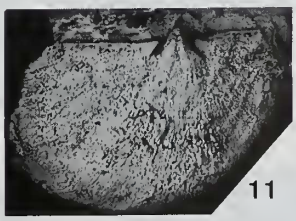
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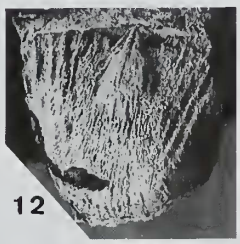
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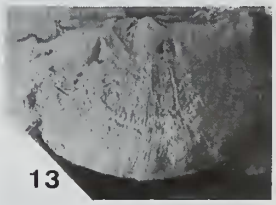
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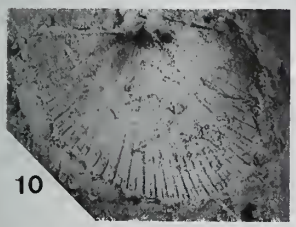
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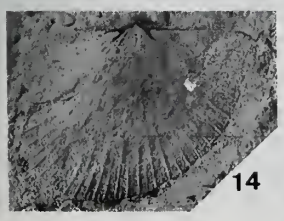
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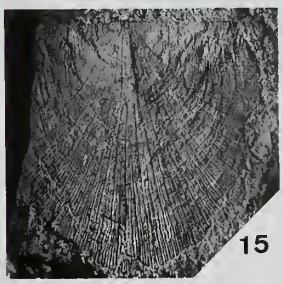
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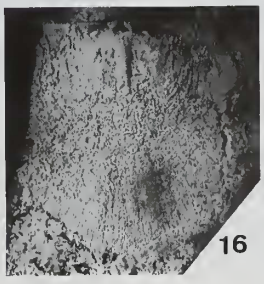
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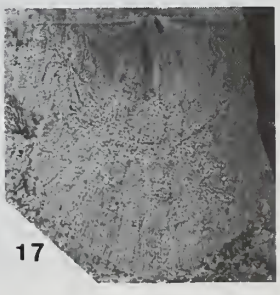
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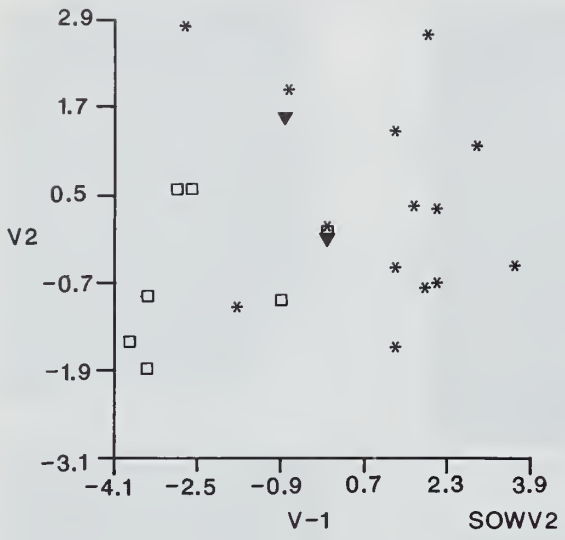

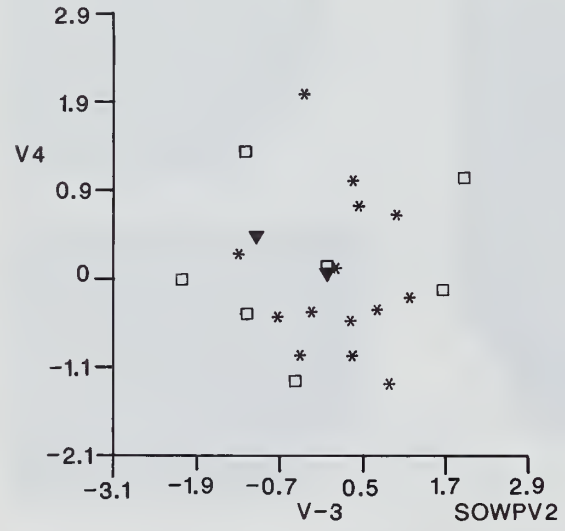

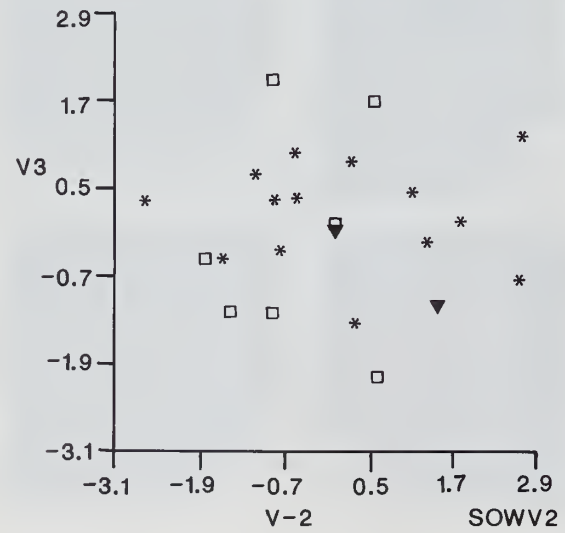

and few well-defined species. Lamont (1953) claimed the record by Reynolds & Gardiner (1896) of *Strophomena expansa* J. de C. Sowerby should be *Rafinesquina concentrica* (Portlock) var. However, specimens collected by Lamont (NMING: F18662, F18663, F18599, F18611) from this locality are labelled as '*R. eirenach* Lamont'. No publication of this species name is known, and the material is kept in open nomenclature, pending further collection and analysis.

Family **STROPHOMENIDAE** King, 1846
Genus ***HEDSTROEMINA*** Bancroft, 1929

Hedstroemina sp. Pl. 14, figs 11–13

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 1: 3 internal and 3 external moulds of pedicle valves; 3 external moulds of brachial valves. Kildare, Grange Hill, Horizon 2: 7 internal moulds of pedicle valves.

DISCUSSION. The restricted sample makes identification problematical, given the wide variation within the genus and the closely related *Kjaerina*. As also noted by Williams (1963: 460), in a very small Bala sample the lack of a strong median rib invites allocation to *Hedstroemina* rather than *Kjaerina*. Hurst (1979*a*: 288) notes four characteristics in Upper Caradoc populations which could consistently be used to separate them, one being the development of weak rugae which is also seen in this material.

Family **LEPTAENIDAE** Cooper, 1956
Genus ***LEPTAENA*** Dalman, 1828

Leptaena sp. Pl. 15, figs 1–7

MATERIAL AND LOCALITIES. Kildare, Grange Hill, Horizon 1: 6 internal and 3 external moulds of pedicle valves; 5 external moulds of brachial valves; 6 indeterminate exterior fragments and 1 conjoined internal mould. Kildare, Grange Hill, Horizon 2: 1 internal and 1 external moulds of pedicle valves; 1 internal and 2 external moulds of brachial valves, all incomplete.

DISCUSSION. The small fragmentary sample is insufficient for statistical comparison with other known *Leptaena* species, and is left under open nomenclature pending better material to assess the variability. Inspection of the ventral muscle field, however, suggests it may be conspecific with *L. ventricosa* Williams from the Longvillian Gelli-grîn Group of Bala.

Fig. 19 Principal component analysis of *Sowerbyella sericea* (pedicle valve internal moulds) from Kildare, Grange Hill Horizon 1 (▼), Kilbride (*) and Carrigadaggan (□). A, Plot of vector 1 against vector 2; B, Plot of vector 3 against vector 4; C, Plot of vector 2 against vector 3.

Family **STROPHEODONTIDAE** Caster, 1939
Subfamily **STROPHEODONTINAE** Caster, 1939
Genus ***HIBERNODONTA*** Harper & Mitchell, *in* Harper *et al.* 1985

Hibernodonta ? sp. Pl. 15, figs 8–10

MATERIAL AND LOCALITY. Kildare, Grange Hill House Cottage: 3 internal and 1 external mould of brachial valves, 2 external moulds of pedicle valves and 3 indeterminate external moulds.

DISCUSSION. The genus and species *H. praeco* were first described from the Clashford House Formation at Herbertstown, Co. Meath by Harper & Mitchell (*in* Harper *et al.* 1985). As an early strophеodontid, the small rafinesquinid-like valves have denticulate hinge lines. The specimens here are tentatively assigned to *Hibernodonta*, since there is an appearance of denticulation on the hinge line, as well as definite denticulate teeth. However, the material is poorly preserved and only three valves have the hinge area present, although the size of the sample is larger than that of the type species. There is no thickened median rib. Until better preserved specimens are collected the material can only be questionably assigned to *Hibernodonta*; it may equally be a strophomenoid species which developed denticulate teeth and sockets, other cases of which are discussed by Harper *et al.* (1985).

Superfamily **PORAMBONITOIDEA** Davidson, 1853
Family **PORAMBONITIDAE** Davidson, 1853
Genus ***PORAMBONITES*** Pander, 1830

Porambonites sp. Pl. 11, figs 21–22

MATERIAL AND LOCALITY. Kilbride: 2 internal moulds of pedicle valves.

DESCRIPTION. *Ventral interior*. Large valves of subtriangular outline, with strong convexity posteriorly. Shallow sulcus originating about mid-length. Faint growth line impressions near anterior margin. Strong teeth supported by high, thin parallel dental plates extending anteriorly for nearly half of length. (Exteriors are unknown.)

MEASUREMENTS. BC 12670: (X1) length = 23 mm, (X2) width = 18·4 mm, (X3) position of maximum width = 16·5 mm, (X4) depth = 7·4 mm; length of dental plates = 11·4 mm (Pl. 11, fig. 22).

DISCUSSION. The material is inadequate for specific assignment, but may be conspecific with the poorly known *Porambonites filosus* M'Coy from nearby Knockmahon, Co. Waterford. *Porambonites* is a common genus in the TLF (Carlisle 1979) and is currently under revision by Parkes & Harper. Significant differences, however, appear between this species and the older one in size, outline and internal morphology.

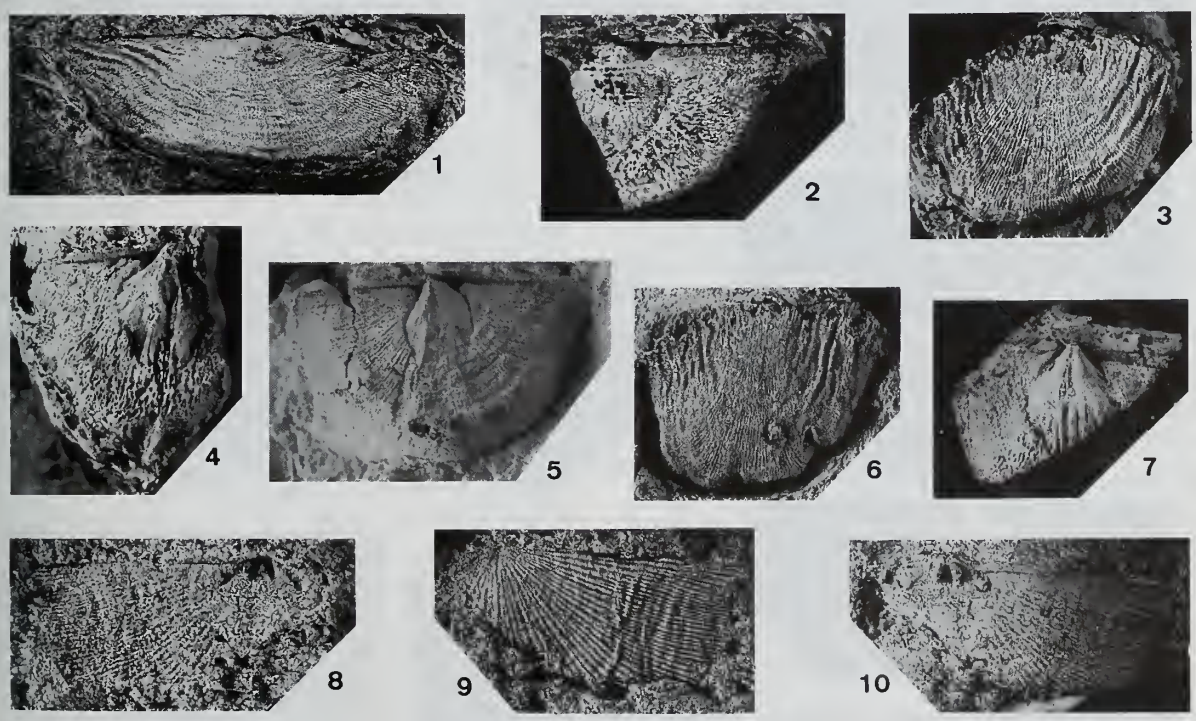

PLATE 15

Figs 1–7 *Leptaena* sp. **Figs 1–4, 6–7**, Kildare, Grange Hill Horizon 1. **1**, BC 12800, external mould of brachial valve, × 2. **2**, BC 12801, internal mould of pedicle valve, × 2. **3**, BC 12802, external mould of brachial valve, × 2. **4**, BC 12803, internal mould of pedicle valve, × 2. **6**, BC 12804, external mould of brachial valve, × 2. **7**, BC 12805, internal mould of pedicle valve, × 2. **Fig. 5**, Kildare, Grange Hill House Cottage, BC 12806a, internal mould of pedicle valve, × 2.

Figs 8–10 *Hibernodonta*? sp. Single specimen from Kildare, Grange Hill House Cottage. **8, 10**, BC 12807a, internal mould of brachial valve, and latex cast, × 4. **9**, BC 12807b, counterpart external mould of brachial valve, × 4.


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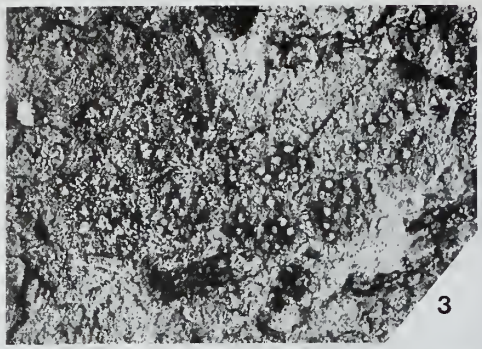
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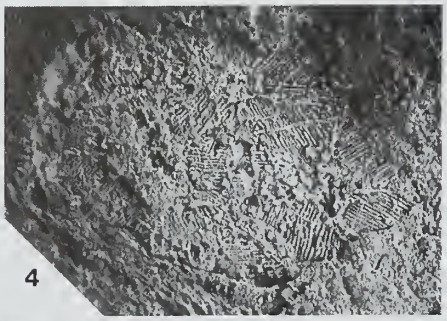
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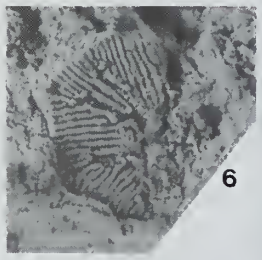
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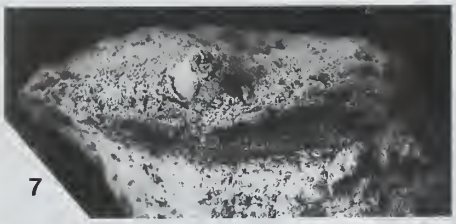
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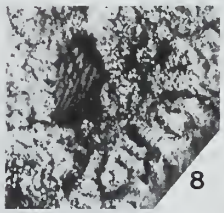
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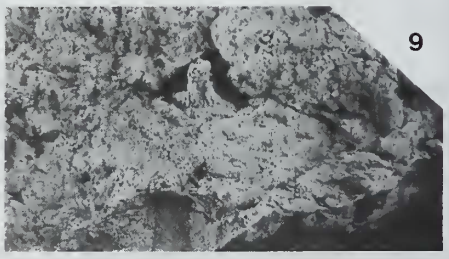
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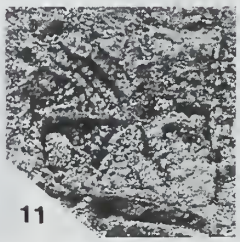
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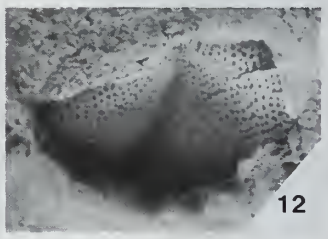
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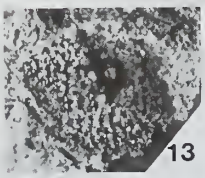
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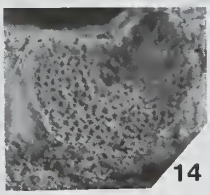
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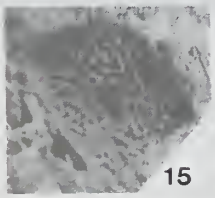
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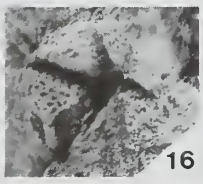
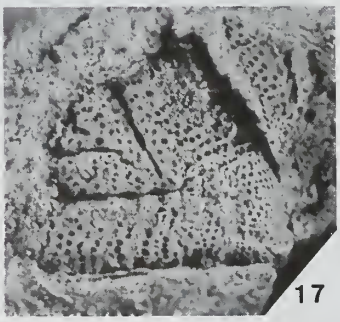

16


17

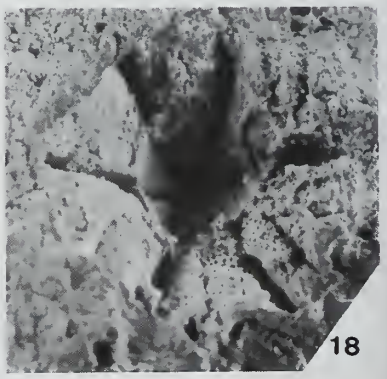

18

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PLATE 16

Figs 1–7, 9–10 *Echinosphaerites* cf. *granulatus* M'Coy. **Figs 1, 3–5, 7, 9–10**, Carrigadaggan. **1**, EE 134, slab with 2 flattened thecae, × 0·5. **3**, EE 136, external mould of several plates, × 6. **4**, EE 137, internal mould of several plates, × 4. **5**, EE 138, external mould of several plates, × 4. **7, 10**, EE 140, flattened theca with oral projection, and top view of same, × 2. **9**, EE 141, internal mould of theca with oral projection, × 2. **Figs 2, 6**, Kilbride. **2**, EE 135, internal mould of single plate, × 7. **6**, EE 139, internal mould of single plate, × 8.

Figs 8, 11–18 Cheirocrinid, gen. et sp. indet. **Figs 8, 11**, Carrigadaggan. **8**, EE 142, × 10. **11**, EE 143, × 6. **Figs 12–18**, Kilbride. **12**, EE 144, × 7. **13**, EE 145, oral plate, × 10. **14**, EE 146, oral plate, × 8. **15**, EE 147, oral plate, × 10. **16**, EE 148, × 7. **17**, EE 149, × 7. **18**, EE 150, × 9.

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